THE JOURNAL

OF THE

RÖNTGEN SOCIETY.

EDITED BY

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WITH THE CO-OPERATION OF THE COUNCIL

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VOL. XIV. JANUARY, 1918. No. 54.

EDITORIAL.

It will have struck our members upon opening the wrapper of the Journal that some drastic alterations have been made; the familiar green cover of the last fourteen years has gone, and the arrangement of the text has been completely changed. These alterations are the result of suggestions made by the recently-formed Editorial Committee, and it is hoped that the result will meet with approval.

Members will by now have received the Booklet which is designed to take the place of the usual "Annual Report and List of Members;" to it have been added some details of the aims and objects of the Society. A number of these booklets will be distributed among radiological centres both at home and abroad, and will, it is hoped, make the Society more widely known.

The foundation of the "Silvanus Thompson Memorial Lecture" was an early suggestion of our President, and was fully supported by the Council; the first lecture will take place very shortly and is sure to be a success.

The new session has opened well, the attendance at the meetings has been good, and the number of new members elected has passed all previous records.

On the occasion of the Presidential Address, reported in this issue, there was a good exhibition of apparatus and a large number of radiographs that recalled the first meeting of the Society twenty years ago. The papers that were read at the December and January meetings are of considerable practical and theoretical importance. We would particularly call attention to the reproductions of X-ray spectra on Plate II., the work of M. de Broglie, that were brought before us by Professor Nicholson in December. We believe that this is the first occasion of the record of M. de Broglie's results in England, and they illustrate the very great advance that has been made in our knowledge of the nature of Röntgen's radiations.

The war has demonstrated the importance of the work of the Society and has indirectly been the cause of a great increase in our membership.

Owing to the fact that the Government has taken over the building of the Institution of Electrical Engineers for official purposes, it has been arranged to hold the meetings of this session at the rooms of the Royal Society of Arts, John Street, Adelphi, W.C.2, and for the future the old arrangement of meeting on the first Tuesday in the month will be adhered to.

SESSION TWENTY, 1917-1918.

OPENING MEETING, held at the rooms of the Royal Society of Arts, John Street, Adelphi, November 6th, 1917. Ballot, see page 31. Address by the President, **Capt. G. W. C. KAYE, M.A., D.Sc.**; Demonstration by **MONS. H. PILON.**

EXHIBITION of APPARATUS and RADIOGRAPHS.

ADDRESS by the PRESIDENT.

X-RAYS AND THE WAR.

By G. W. C. KAYE, M.A., D.Sc., Capt. R.E. (T.)

There was once a time in my salad days when, having suffered several addresses at the hands of various presidents—I hasten to add not of this Society—I vowed to myself that if for my sins I ever became President of a learned Society, the last thing I would do would be to inflict an address on a long-suffering audience which had just done its best to offer a signal compliment. I can only say in extenuation of my address to-night that time has weakened my resolution and circumstances have modified my views.

I am very sensible of and grateful for the high honour you have paid me, and I trust that my year of office will be no less profitable to the Society than those of my distinguished predecessors. With your support I hope for a stimulating session, despite the troubled nature of the times.

We have sorrowfully to record the loss of Mr. Wilson Noble, the third President of this Society. He was greatly esteemed both as a brilliant radiologist and as a man. The Society has also to mourn the sudden loss of Mr. Duddell—a former President and a Vice-President up to his death. A scientist of the very first order, a man of engaging personality, his loss in the prime of life will be acutely felt by all members of the Society.

There are very few societies in which the general camaraderie is so pronounced as in the Röntgen Society, and I know of no other society whose meetings one is almost invariably able to leave with the feeling of having spent a most profitable and, sometimes, amusing evening. This good fellowship has, I gather, always been a feature from the early days, when this, the first of all Röntgen Societies, was founded. The formal inauguration of the Society took place at St. Martin's Town Hall on November 5th, 1897, so that to-night we celebrate, within a day, the twentieth anniversary of our birth. I am glad to say the Council has decided to-night to commemorate the auspicious occasion by founding a Silvanus Thompson Lecture in memory of our first President. It is intended to invite distinguished scientists to give this lecture, year by year.

At this first meeting there was a large and distinguished audience and the late Professor Silvanus Thompson gave the new Society a splendid send-off with a brilliant Presidential Address. Then, as now, the constitution of the Officers and Council was half medical men and half scientific laymen. In the early days scarcely any medical men possessed the necessary apparatus for generating X-rays and they had to turn to their scientific friends for help and co-operation. The union of forces was productive of the happiest results and the co-operation has continued and will, I trust, continue for all time. Both sections of the Society will, I am sure, acknowledge

the stimulus and help which each has derived from the joint association; and the great majority of medical radiologists are only too ready to give the physicist the recognition which is his due, not only for past work but in the work to come from future co-operation.

It would, I think, be all to the good if a more thorough study of the X-rays formed part of the physics course of the medical student working for the first M.B. I have had a good deal to do with examining medical students in physics and have learnt much from them on subjects not altogether connected with physics. Some of them surprise you at times with the wealth of their knowledge. I remember once setting a question on Ohm's law and got the answer from a budding medico that "Ohm was a Royal Engineer officer employed by the Board of Trade, who, having one day discovered a law, persuaded the Government to put it into force."

It was close on two years before our first formal meeting that Röntgen stumbled, so to speak, across a new type of radiation, the wonderful properties of which excited the whole civilized world. It was the ability of the new "X" rays to produce shadowgraphs of the internal structure of optically opaque bodies that attracted the attention of all and sundry; and as time went on the art of radiography gradually extended into fields once never dreamt of. A present-day development very typical of the times is the detection of contraband metals, the examination of autogenous welds, and the scrutinising of steel and other metal castings and plates for faults and blow-holes. Such work demands high voltages and the heaviest outputs. Already steel plates over one inch thick have been successfully examined. A series of lantern slides illustrating this work—which promises to be of great war importance—will be shown to the Society immediately after this address, by Mons. Pilon from France. We are very glad to welcome him here this evening.

But the all-important use of the X-rays and the one dominant in our minds to-night is their medical application. Every hospital of any size now has its X-ray department and there are many thousands of radiologists—both medical and laymen—devoting their lives to the work. By their aid miracles are literally being wrought daily.

The part which the X-rays have played in the present war has been a veritable triumph, and incidentally a liberal education for the medical man not yet converted to the view that a knowledge of radiology should form part of the stock-in-trade, not only of the specialist, but even of the overworked G.P. X-ray technique has, in fact, improved so vastly as to give the diagnostic methods of physicians and surgeons a facility and exactitude never deemed possible at one time.

The use of X-rays begins early in a soldier's life. If, as a recruit, he shows evidence of disease, the radiologist is called in to help to decide the man's category and his future sphere of usefulness to his country. Nothing could be fairer, but the ancient and noble professions of malingering and "swinging the lead" have received several nasty set-backs this war.

In the large military hospitals the great majority of wounded soldiers are X-rayed—they all ought to be, but unfortunately it is not always possible—and be it put on record, unless he has his "picture taken," no matter what the complaint, that soldier will leave the hospital a "grouser" with a deep sense of injustice rankling within him. My three years' experience of the British soldier has filled me with boundless admiration of his acumen—he unhesitatingly knows a good thing when he sees it. More power to him!

The X-ray examination of wounds and injuries has become routine practice, whether in the field, by the use of the ingenious and cleverly designed motor-lorry outfits, or in the base hospitals. The X-ray is as indispensable as the dressing or the splint, and it is an essential adjunct in prescribing and directing, as well as avoiding operations. Even sprains are radiographed to find whether there is any slight bone fracture—as there very often is. Limbs are saved and cripples uncrippled by the use of X-rays and the new antiseptic treatments.

The X-ray detection of embedded bullet and shell fragments is now so certain as to be commonplace. Bullets and shrapnel are found and removed from any part of the body, even from the lung and brain or in the region of the heart. The rays have revealed some miraculous bullet tracks in the body and elucidated confusing symptoms.

X-rays may be used to guide the surgeon during his actual efforts to remove the foreign body. Precise instruments for localization in the operating theatre are now in use, and even during the operation itself the surgeon's instrument may be guided to the foreign body. Stereoscopic fluoroscopy is possible, and if a practical apparatus could be produced it would be of incalculable value to the surgeon and radiologist in their combined efforts.

Unless there is a suspicion of septic poisoning a bullet is generally best left alone, and, incidentally, I understand the knowledge of the existence of a resident bullet within him has on occasion not been entirely without its value from the soldier's point of view so far as "leave" is concerned. Shell fragments are usually dirty and the nature of the damage they inflict along their course makes it important that their exact position should be known.

It is in such cases that X-ray stereoscopy attains its fullest delicacy. For example, the location of small foreign bodies near the eye or actually in the eyeball can be carried out to the hundredth of an inch. Such precision is, of course, only possible in the big base hospitals. The central clearing stations are also fitted with locating devices, and it is indeed possible to do locating with a portable outfit. A very fine example of localizer, designed by M. Baese in Italy, will be on view after the meeting.

I need not dwell on the many stereoscopic methods which have been proposed and used. I will only say that Sir James Mackenzie Davidson, whom we are proud to claim as a past president of the Society, must be happy in the knowledge of the development of X-ray stereoscopy and the value of the work in which he was the pioneer.

In the case of a fracture, the stereoscopic radiograph reveals the direction of the fracture and the disposition and intimate lamellar structure of the broken bone, and so assists the surgeon in deciding on the method of reparation. In some cases of fracture the bone is shattered into many pieces—" absolutely gone west," as the patient would probably explain to the doctor. Some of these, cut off from their blood supply, die and can be differentiated by the X-rays from others which are still alive and likely to join together in useful fashion. The fragments which the radiograph reveals as dead or likely to die are removed early by the surgeon and the cure is thus expedited. After the bone has been set, the progress of the recovery can be clearly followed in the subsequent photographs—whether the parts are joining up, whether new material is forming. The sequence of radiographs is included in the record of each case. The total number of photographs already taken at the

various hospitals since the war commenced amount to many hundreds of thousands. Very valuable data will be obtained when time allows the radiologist to go carefully over all the accumulated records of cases.

The value of the X-rays in diagnosing chest complaints has been established again and again in this war. This is the case particularly with incipient tuberculosis, where early diagnosis is of great importance. Not only the diagnosis, but the treatment of tubercular glands has been attended with considerable success.

Great attention has been paid in this war to the soldier's teeth, and very rightly. Such treatment, including in many cases the provision of artificial teeth, is provided at the State expense. Here again the X-rays are playing their part, and dental radiology has become a very important subject. By inserting a photographic film in the mouth, radiographs of individual teeth can be obtained, revealing in perfect fashion the condition of both the tooth and the surrounding bone. *À propos* of teeth, most radiologists are familiar with the patient who has been racked for years with throat and digestive troubles, and has chased the world round in search of cures—especially in Germany—and has finally been shown by the X-rays to be suffering from unsuspectedly bad teeth with the attendant septic poisoning.

I cannot do more than mention the splendid work of "opacity" radiology, which can diagnose with routine certainty diseases of all parts of the alimentary canal. This again has been of great service in examining recruits of doubtful medical fitness.

A word should be said on the invaluable results obtained from shortening exposures, especially in heart and lung conditions. To my mind the pitch of excellence which single impulse radiography has attained is nothing short of miraculous. Flash radiography is particularly valuable in the case of children, and first-class radiographs using exposures from 1/100th to 1/500th second can be obtained, even with the child wriggling about on the plate.

One of the most successful workers in this and indeed all branches of radiology is our secretary, Dr. Knox, who has been kind enough to criticise and amplify what I have written on the medical aspects of radiology—a subject on which I can, of course, lay no claim to speak authoritatively.

Another war development of radiology is its employment by the orthopædic surgeon in his efforts to restore damaged limbs. Most of us have personal knowledge of the triumphs of the association of this branch of surgery with radiology in supporting the future existence of our maimed heroes from overseas.

But the beneficent effects of the X-rays do not end with radiography. They have achieved wonderful results, not only in the diagnosis, but in the repair of wounds. Amongst the minor tragedies of the war, few are more pathetic than the ghastly mutilations and disfigurements caused by shell wounds of the face and head. Many of our wounded soldiers would never dare to expose their faces for very shame and the horror of their fellow creatures. Fortunately it is often possible to restore these men to a comparative degree of ease and comfort and save them from a life of perpetual misery and humiliation. By the wonderful plastic or reparative operations of the surgeon they can be restored to at least a semblance of their former selves. Lips are renewed, a new nose built up, eyelids replaced, cavities in the palate filled in, by this new grafting process. For wounds of the mouth, flaps are taken from the skin, and for wounds of the face they are taken from the scalp. I would pay tribute to the extraordinary skill and ingenuity exhibited by surgeons in their efforts to remedy these terrible deformities.

Much valuable work has been done in all countries in this direction and it is a pleasure to me to be able to call attention to what is being done by British surgeons. I need only refer to a paper published in the *British Journal of Surgery* for July, 1917. This Society has been indirectly associated, through Dr. Knox, with the reparative work of this nature which Mr. Percival C. Cole is carrying out at the King George's Hospital and the Cancer Hospital.

The radiologist's part in such work is to render scar-tissues pliant, to depilate hair from the scalp and skin surfaces concerned, to render the flaps pliant and more adaptable to their new positions, and to stimulate generally the healing process in both flaps and bone. For these purposes he employs radiation treatment, either X-rays or radium rays. Ionization methods have also been employed in this work and the use of massage is of great value. In wounds of the mouth the dentist provides splints and moulds and also plays a valuable part.

It must afford great satisfaction to all of us to realize that British surgeons and radiologists working hand in hand are engaged in pioneer work of such an important and interesting nature, and that the surgeons of this country are exhibiting a foresight, skill and ingenuity which are at least equal to those exhibited in any other country. I believe the employment of radiations in this connection as an aid to surgery is real pioneer work, for so far I have seen no reference to it in any recent literature.

A number of photographs illustrating this plastic surgery are on exhibition this evening and these, together with many perfect examples of the general radiographic war work of several members are well worth your closest attention.

In the treatment of septic wounds and persistent sinuses, the most extraordinary success has resulted from a combination of X-rays and ultra-violet rays. Hyperthyroidism or "soldier's heart" produced by over-action of the heart through nervous strain has been successfully treated by X-rays and radium rays.

The electro-therapeutist has also been prominent in war work. Countless electrical departments have been established in military hospitals throughout the country for the treatment of war injuries. Quite one-half, if not more, are gun-shot wounds of the nerves with paralysis of the muscles. These cases are sent for electrical examination of the injured nerves and subsequent electrical treatment. Many such patients with paralysed limbs are very slow in their recovery and are discharged as unfit for further service, but the continuation of electrical treatment is of the utmost importance if a useful limb is to be obtained.

The subject of the diagnosis and treatment of cases of paralysis by electrical methods, such as the application of continuous and interrupted currents and condenser discharges is being studied on a scale never before possible, and invaluable additions to our knowledge of the pathology of therapeutic methods have been made. In this connection attention should be called to the pioneer work of the late Dr. Lewis Jones, one of the original members of this Society.

Many cases of war wounds, more particularly those of the uncomplicated, but inert, type which refuse to heal, are treated electrically. Simple application of a direct current stimulates the process of repair and sluggish wounds at once begin to heal. "Trench feet," which occurred in large numbers last winter, receive benefit by electrical treatment, some by ionization, others by high frequency treatment and diathermy. Electrical methods are also largely used in the softening of hard scars following extensive wounds and causing impairment of movement and fixation

of joints. Cases of shell-shock and neurasthenia and other functional disorders of the nervous system, some of which are seldom or never seen in times of peace, are now being cured in large numbers by electrical treatment. A mere mention must suffice of the value of the electro-cardiograph in the diagnosis of cardiac conditions.

New apparatus has had to be invented by the electro-therapeutist to meet the calls of the various treatments, and old apparatus has been adapted in many ways.

I am indebted to Dr. Cumberbatch for the information which has enabled me to give an up-to-date account of the excellent war work done by the electro-therapeutist. The part that electricity can play in the treatment of injury and disease must lead in the end to a fuller recognition of a branch of medical work which has hitherto not received the credit it has deserved.

And so the story goes on. Who will deny the glorious part played by the X-rays in re-establishing shattered and mutilated humanity, and who will withhold an appreciation of the skill and unwearying patience of the radiographer, both medical and layman, whose practised vision detects significant markings which would pass unnoticed by the uninitiated, and whose training and accumulated experience enable him to provide the surgeon with the true interpretation of his wonderful shadow pictures ?

And have not the radio-therapeutist and electro-therapeutist found their reward in the gratitude of many men to whom they have once more made life endurable ?

When the humanitarian side of the war is chronicled the rôle played by the army of radiologists will be set out for all to read. As a society we are proud to think that a large proportion of our members have contributed and are continuing to contribute no mean share of that success. And when the time comes to review our triumphs I trust the work done by the pioneer members of this Society in the early days of X-rays will not be forgotten—some of them in their search for knowledge made the supreme sacrifice.

I now propose to turn for a while to the physical aspect of radiology. The troubled state of the times is responsible for the present meagre research output in the X-ray world. But a good deal of fundamental work has been done during the last few years, and to begin with I would like to say a word or two about the X-ray tube—the ruling factor in both radiography and radiotherapy.

The outbreak of the war found the X-ray manufacturers, like everybody else, quite unprepared. The greatest credit is due to them for the splendid way they threw themselves into the breach and turned out in record time unprecedented numbers of outfits for the Army—not second-class stuff, but as good as has ever been made.

The X-ray bulb manufacturer was at once confronted with the absence of the glass which Germany had hitherto supplied. The English glass manufacturer had to face the task of producing a uniformly good glass which would stand up, without puncturing, to the high voltages which obtain in practice. The problem was very difficult, but is gradually being surmounted by State aid. In the meantime our American and French friends came to the rescue. We are all awaiting the publicity which the X-ray Committees of the War Office and the Department of Scientific and Industrial Research are doubtless seeking for the results of their various experimental enquiries.

It is remarkable how slight have been the changes in design experienced by

the target tube, introduced in 1896 by Sir Herbert Jackson, past President of this Society. He would be a bold man, nevertheless, who would assert that the present design has approached finality or anything like it. All X-ray tubes are, in fact, extraordinarily inefficient things. The heat they generate is proof of that. Under favourable conditions we make use of rather less than one part in one thousand of the energy we impart to the cathode rays in an X-ray bulb. Small wonder then the atmosphere of profanity which Mr. Cuthbert Andrews assures us surrounds all X-ray bulbs.

The numerous varieties of X-ray bulbs differ only in detail. Nearly all their well-known peculiarities are due to a never-ending variation of the gas pressure produced by local emission and absorption of gas by the electrodes and glass envelope. In some tubes the self-adjustment is complete for a definite load on the tube, which thus works well. A slight alteration of the conditions disturbs the adjustment and the tube becomes cranky, to recover possibly after a rest. It is the question of gas pressure, as well as the space and surface electrification depending on the disposition of the cathode, that is responsible for the fact that two X-ray bulbs, running under the same conditions of current and voltage, do not always emit beams of the same composition.

Coolidge realized all this and cut the Gordian knot very simply by removing entirely this surface-bound gas by a process of exhaustion more complete and prolonged than had ever before been applied to an X-ray tube. The final steady pressure was less than 1/20th of that of an ordinary bulb, the result being a vacuum so good that no discharge could be passed in the cold, neither positive rays nor cathode rays being generated by any available voltage. Coolidge solved that difficulty by inserting a hot-wire cathode, the pioneer work on which had been largely worked out in this country at the Cavendish Laboratory at Cambridge.

The Coolidge tube has been on the market nearly four years. It has been considerably improved in detail and now claims pride of place among X-ray tubes. It is not entirely free from defect, and its rays are no more homogeneous than those from an ordinary bulb, but its elasticity, precision, ease of control, long life and relative freedom from inverse current make it an invaluable addition to the radiologist's equipment. The British Thomson-Houston Co. have very kindly lent me an example of a new smaller model which gives very good focussing. This will be on view later in the evening.

Some wonderful output figures have been obtained by Coolidge on experimental water-cooled models. One tube was run continuously for many hours at 200 milliampères and 70,000 volts, the power input being 14 kilowatts, *i.e.*, about 19 H.P. It is anticipated that this figure will be shortly increased to 50 kilowatts. This has become a job in which we *must* have the electrical engineer's co-operation, a remark which applies equally well to the design of all high-tension generators.

It was hoped on its introduction that the Coolidge tube would be the means whereby X-rays approximating to the hardest gamma rays from radium would be obtainable. Such anticipations have not been realized. In some recently published work, Sir E. Rutherford describes measurements on the very hardest rays emitted by a Coolidge tube excited by close on 200,000 volts (*i.e.*, about 14 inch spark between points) —very near the safety limit of the tube. In order to filter out the hardest rays present, he passed them through 1 cm. of lead, the reduction in intensity being over a million fold. Searching for the residual rays after such treatment is rather

like the classic example of a blind man looking in a dark room for a black cat which wasn't there.

Rutherford's well-known experimental genius overcame the difficulty. The residual rays were practically homogeneous and proved to have a wave length of about 0·06 Å.U., which may be compared with Rutherford's latest estimate of the wave-length of the hardest gamma rays from Radium C—between 0·02 and 0·007 Å.U. In other words, the Ra gamma rays in question correspond to X-rays generated by voltages between 600,000 and 2,000,000—figures to which no X-ray tube of present-day design could possibly stand up, even if we had the means to produce such voltages on a practical scale.

We have evidently a long way to go before we can imitate the processes within the radium atom.

As to the composition of the X-rays generated by an X-ray bulb. We have always been led to regard the rays as amazingly complicated. So they are, but we do know now, at any rate, that the rays consist in general of two groups,

(*a*) a continuous spectrum of rays with a sharply defined boundary on the side of shorter wave-lengths, the position of such boundary depending on the voltage on the tube.

(*b*) One or more characteristic radiations (—J, K, L, M,—series), each approximately homogeneous and characteristic of the metal of the anti-cathode. The higher the atomic weight the more penetrating the radiation in the same series.

The proportion of (*a*) and (*b*) depends entirely on the conditions. With very soft tubes a large proportion of the radiation may be wholly characteristic.

With reference to the spectrum of general rays, which are the rays most used in radiography, one positive fact emerges. It has recently been shown that the maximum frequency (or hardness) of X-ray which a tube can yield can be readily calculated by a simple extension of Planck's quantum theory. The relation in question (due to Einstein) is

$$Ve = h\nu.$$

where V is the voltage on the tube,
e the elementary charge on each cathode ray,
ν the frequency of the hardest X-ray produced,
h is a universal constant.

In other words, the wave-length of the X-ray in question is inversely proportional to the voltage; e and h are known with considerable exactness, so that we have the means of calculating very readily the wave-length of the hardest X-ray generated by a given voltage on a tube, or *vice versa*, the voltage necessary to generate a particular X-ray. I think you will agree this is a big step fowards simplification.

Inserting Millikan's latest values of these constants, published this summer, we have

$$\text{Wave-length in Å.U.} = \frac{12{,}400}{\text{voltage.}}$$

The accuracy of this simple relation has been confirmed experimentally over a wide range of voltages in America. It will be noticed that the result is independent of the material of the anti-cathode.

The large admixture of many longer waves with the Einstein ray is no doubt due to a number of secondary causes.

With reference to the characteristic radiations, each consists of a number of spectral lines. For these, Einstein's simple law does not hold, a greater voltage being required to generate the radiation. Webster noticed that the various spectral lines of a series all spring into being together as the voltage is increased through the critical value.

I attempted in some experiments before the war, to obtain a notion of the proportion of characteristic to continuous radiation. The method was essentially one of progressive filtration. A series of absorbing plates were used and the absorption curve was plotted and analysed by simple graphical means.* There was no difficulty in "spotting" the well-known characteristic radiations and estimating their amount.

The medical man has put many posers to the physicist since X-rays were discovered, and one of his most insistent demands has been for a method of generating homogeneous X-rays in great abundance and of the right quality to be useful in practice. The task is as difficult as the corresponding problem in visible light. It was hoped at one time that to run an X-ray bulb with a constant voltage would yield monochromatic X-rays, but experiment unfortunately shows that the composition of the rays is precisely the same as when the bulb is excited by the intermittent potential of an induction coil under the same conditions.

There is one gleam of hope. It is known that to generate a characteristic radiation requires a definite minimum voltage and that when that radiation is generated, the rest of the spectrum is enfeebled. What is also important, the tube at the same time becomes more efficient from an energy point of view. In other words, as the voltage is raised through the critical value, the tube not only increases in efficiency, but begins to emit a considerable proportion of homogeneous rays. The softer rays present can be removed by filtration by a screen of an appropriate metal. To ensure the greatest homogeneity, therefore, apply the voltage which is known to excite to advantage the particular characteristic radiation required from the anti-cathode, and screen out the softer rays present.

The work to be done will guide us in selecting an anti-cathode which will emit a suitable characteristic radiation under a convenient voltage. For example, for radiography, the K radiations of the heaviest metals, tungsten, platinum, uranium, etc., are sufficiently hard for the purpose. The voltages required range from about 80,000 to 160,000 volts, the exact figure depending on the metal chosen.

If softer rays are required for therapeutic or other purposes, use an anti-cathode of lower atomic weight (taking care that its physical properties make it suitable for the purpose), apply the right voltage to generate the characteristic radiation in question and remove the softer rays by absorption. If we want harder rays we do not increase the voltage, as that will chiefly strengthen the general spectrum of rays; we simply choose another tube with an anticathode of greater atomic weight.

Thus for our several purposes we shall provide ourselves with a battery of tubes (probably of the Coolidge type) each with a different metal for the anti-cathode, and each labelled with (1) the appropriate voltage for exciting the useful characteristic radiation of the anti-cathode in question; and (2) the appropriate absorbing screen—its nature and its thickness. Such voltages and thicknesses are either known or can readily be calculated.

I think the plan is worth trying. I have not yet had the opportunity of doing

* See Kaye, Proc. Roy. Soc. A. Vol. 93, p. 427, 1917

so, but I do know it is very successful with metals of medium atomic weight excited by appropriate voltages. In such cases I have managed to obtain 90 per cent. homogeneity, though I do not think we should meet with this degree of success with the heavier atoms.

The heterogeneity of the rays in ordinary practice is chiefly responsible for the complexity of the dosage question in radiotherapy. The different dose-meters which have been employed all display marked selective effects—they do not register the different rays proportionately to their energy. Some of the methods are decidedly inconvenient, and not one of them is as yet of any value as the basis of a precision instrument. They should all be regarded as nothing more than the roughest of guides, calculated more to reassure the patient rather than the doctor. For most purposes, at any rate with tubes of the Coolidge type, we cannot do better than read both voltmeter and milliammeter. Both are important and their joint readings are valuable when flavoured with a strong dash of experience.

The Dosage Committee appointed by the Society has done useful work and would have done much more if the war had not interfered with the activities of its members. There is still much for it to do, but decisions cannot be come to in the absence of completed research. The problem ought not to be insoluble, for great precision is unnecessary in standardizing a process which is not so much physical as physiological in character.

There are numerous other points of practical interest to the X-ray worker, such as the relative advantages of the induction coil and the interrupterless step-up transformer—a subject to which I think we ought to devote an evening this session.

But time forbids to-night and I am anxious to say a word or two on the part the X-rays have played in molecular physics. Through the medium of the X-rays we have unveiled a few of the secrets of the structure of the atom. The biggest development has resulted from the discovery of the wave-like character of the X-rays. It was Laue and his pupils in 1913 who first demonstrated the diffraction of X-rays by crystals, but it was in this country that the first real insight into the problem came.

The Braggs (father and son) showed how the crystal reflection of X-rays could be utilized to separate out different waves in a fashion exactly analogous to the production of interference colours by thin plates. The X-ray spectrometer revealed both the atomic spacings of a large number of crystals and the absolute wave-lengths of a variety of monochromatic X-rays.

The work of Moseley stands out pre-eminently here. It is a sad comment on the ill-preparedness of this lack-a-daisical country for war in that it allowed so brilliant a scientist to go out as a combatant officer to Gallipoli to meet an untimely end. Moseley, working in Manchester and Oxford, had photographed many characteristic X-ray spectra and measured the wave-lengths of the principal lines. He was able at once to obtain a very remarkable and simple relation, namely, that the frequency of a characteristic X-ray from any element was proportional to the square of the atomic number of the element.

This atomic number must be distinguished from the atomic weight. It denotes merely the order in which the elements come when arranged according to their atomic weights. Thus the atomic number of hydrogen is 1, of helium 2, of lithium 3 and so on. The atomic numbers follow the order of atomic weights, except in three instances; Argon and Potassium, Cobalt and Nickel, Iodine and Tellurium are interchanged.

The X-ray spectra are revealed as an extreme type of light-ray spectra, and are even more characteristic of the parent atom. Later work has shown that X-ray spectra contain many lines and are much more complicated than was first believed.

Moseley's relation reminds us of the well-known though much more involved relations in optics, in which the frequencies of homologous lines in the spectra of associated elements have been found to be proportional to the square of the atomic weight.

Moseley's work has been extended by others, notably by Siegbahn and Friman. We now know the atomic numbers of all the known elements, beginning with hydrogen and ending with uranium—with an atomic number of 92. Each of the atomic numbers is represented by an element, with the exception of numbers 43, 61, 75, 85 and 87, which stand for five elements waiting to be discovered. Two of these five come in the radio-active group of elements. It by no means follows, however, that there are only five missing elements; five is a lower limit, for we now know that several elements may have the same atomic number and this applies especially to a number of radio-active elements with transitory careers. Such isotopes, as Soddy has called them, cannot be distinguished one from another by ordinary chemical or physical tests. They are grouped together under the one atomic number in the periodic classification of the elements, but, nevertheless, they may, and do possess atomic weights differing by several units.

It is apparent that the atomic number is something more than a mere integer; it undoubtedly represents some fundamental attribute of the atom. Now the work of Rutherford, Bohr, Nicholson, and others makes it a practical certainty that the atom consists of a concentrated nucleus round which circulate rings of electrons. The nucleus contains both positive charges and negative electrons, but there is an excess number of positive charges equal to the number of electrons in the surrounding rings, the whole atom thus being electrically neutral. Now several quite different methods of experimental attack all agree in indicating that the atomic number equals the excess number of positive charges in the nucleus of the atom; and this discovery gives the atomic number the significance which it had assumed.

We are led to the views of a school of thought which no longer regards the atomic weight as a constant of an element, but holds that an element is defined more characteristically by features depending on the nucleus of the atom rather than on the atom itself. On this view then, there are only ninety-two elements though many more kinds of atoms, and isotopes should be regarded as varieties of one and the same element, some varieties consisting wholly of atoms of the same weight, others consisting of atoms of different weights.

The complicated character which X-ray spectroscopy has taken on has proved a little disappointing for those who, flushed with Moseley's early triumphs, hoped that there were about to be revealed at last fundamental molecular secrets which would not appeal only to the mathematician. But Nature is as elusive as the Hun, and what has proved to be the case is that, while we have advanced a few molecular miles over some very difficult country, studded with corpuscular "pill-boxes," we have still a long way to go before we can achieve the complete success for which we are all hoping. I trust that the military situation which has given me my parallel will not be equally slow in developing.

I have dwelt at some length on emission X-ray spectra. It remains only to mention the work by de Broglie and others on absorption spectra. It has been

known for a long time that the absorption of X-rays markedly increases as soon as a characteristic radiation is generated. The change is very sudden and if a photograph is taken by passing a spectrum of X-rays through a metal plate on to a photographic plate the result is a series of sharp absorption bands characteristic of the absorbing metal. This new method of attack gives great promise and the Society will have an opportunity of seeing some of these absorption spectra at the next meeting, thanks to the kindness of Prof. Nicholson.

I should like in passing to say a few words about the spectrum, the boundaries of which have been widely extended in both directions during the last few years. To-night we are interested not so much in the red and infra-red end of the spectrum as in the ultra-violet and the regions intervening before we come to the excessively short waves which we now identify with X and Gamma rays.

In the ultra-violet, Lyman has extended the region first investigated by Schumann to a wave-length of about 500 Ångström units, and Richardson and Bazzoni have very recently further extended this to 420 Å.U. The longest X-ray so far measured by Siegbahn has a wave-length of 12 Ångström units. Rutherford has recently given evidence for believing that the wave-length of the hardest Gamma rays from Ra C is in the region of 1/100 Å.U. We are thus now familiar with a range of over ten octaves of X and Gamma rays without a break—not at all a bad record for so young a subject. There still remain about five octaves to be explored in the region between X and ultra-violet rays, a region which contains the characteristic X-rays of the light elements from hydrogen to neon.

It is interesting to consider for a moment what happens as we pass from visible light to Gamma rays. Visible light rays have little penetrative power for those solids we conveniently call opaqne; they can, however, penetrate for enormous distances media whose atoms are not so closely packed, such as air and the ordinary gases, this being especially the case with the red rays. This penetrating power is gradually lost as we pass into the ultra-violet, the Lyman rays being very powerfully absorbed by gases. The same is true at the other end of the unknown region, where vacuum spectrometers are essential in experimental work on the long-waved X-rays. As the wave length diminishes the rays re-acquire penetrating power, not only now for gases, but for all classes of media. I need not remind you of the intense penetrating power of the hardest Gamma rays which will, in fact, go through anything. In the unknown region we pass from an atomic to a corpuscular absorption and we can only hope that in the near future the whole of this region will be surveyed.

And now to turn to quite a different topic. At the moment we are all reproaching ourselves for our past neglect of science in this country. It was time we "got the wind up"—to use the soldier's familiar expression—for in very truth we are paying the penalty of our indifference, despite the wonderful adaptability and resource which this war has shown we possess as a nation.

The course of events has made it evident that the country badly needs men with knowledge who can think and act, for there are still many incompetents in authority to be weeded out. It will be a long time before peace "breaks out" and the last "All clear" signal sounded; and in the meantime every scientifically trained man should be in his place doing effective war work.

The country is slowly learning its lesson. Willy-nilly, we are being led to see at last that our system of education misdirects much genius into unproductive channels; we are agreed in condemning the limited outlook of the average British

manufacturer who prides himself on his sturdy independence; we are making the amazing discovery (though very slowly) that a politician is not necessarily the best man to administer a highly technical department or control our system of education; and above all we are awakening to the importance of research both pure and applied.

The value of applied science to industry is now accepted throughout the country and British industry should begin to feel the benefit, especially now that the principle of State-aided research is established. But in the midst of our new-found appreciation of applied research, I would wish to add my voice to those who are also urging the claims of pure research. This is not so much for the present time as for the days of peace to come, for unless it has an immediate bearing on some war or national problem, speculative research should rightly stand aside till the war is over.

But when it is no longer a question of "need's must" we must not forget that it is the pure academic research, unrestricted and unprescribed, which has been the prime cause of all the radical changes in industrial methods. As Sir J. J. Thomson has aptly remarked, "The discoveries in applied science may produce a reformation: those in pure science lead to revolutions."

Research in pure science is rarely appreciated by the general public or manufacturer, for it cannot be done to order; it is never possible to foresee the ramifications which an enquiry may assume. One must put faith in the research worker that he may continue to have faith in himself. Much of what he will do will be discontinuous and abortive, but he must not be hampered by utilitarian notions being continually rammed down his throat. If he does not solve the original problem he will probably solve some other which has sprung from it; and one successful discovery may outweigh by far all his failures.

As an illustration, take the work of the "ionic" school. Ten or fifteen years ago it was considered by many to be speculative and theoretical to a degree, but it has since yielded results of great technical and scientific value. Among other things we may claim for it, apart from the X-rays and the part they have played in this war, radium paint for luminous dials—which have been of the utmost assistance to our flying men; high-potential rectifiers; thermionic detectors—now invaluable in wireless telegraphy and telephony; the X-ray examination of metals by the metallurgist; the half-watt and the point-o-lite lamps; our knowledge of the structure of the atom; the triumphs of radium therapy; an estimate of the age of the earth and the explanation of atmospheric electricity and of aurora. As another development we may recall C. T. R. Wilson's recent experiments on lightning, in which he was able to show that an average lightning flash discharges over 20 million volts, is about 6 miles long and possesses energy equal to 60 tons falling through that distance to earth.

These examples will serve. I will only add that I do not for one moment lose sight of the equal importance of the applied research worker who is responsible for turning to account the discoveries of the pure scientist. There is in fact no line of demarcation between the two divisions of research. Each involves study, hard work and thought. The methods of both branches are questioning and searching; the common end is knowledge, to which there is no Heaven-sent road. We are told that the greatness of a man is the result of two-fifths birth and three-fifths environment, and it is very certain that a man or woman of the right type can find no better environment than that which a school of research provides. Its educational value in moulding character and outlook is beyond compare.

And what has been the reward of the research worker in the past? It is the shameful truth that we have done our best to starve him. The man of science with few exceptions has received little or no recognition by the mass of the people of this country, who, unknowing and uncaring, have been perfectly content to allow him the status, both social and financial, which he himself has modestly sought for his every-day life and wants.

But the country is awakening to the truth, if slowly, and fortunate it is that since the war began this country has led its leaders, for until recently the indifference and apathy of its politician administrators to science were only equalled by their complete and abysmal ignorance of such things.

In one sense the man of science is also responsible for his lack of recognition, in some cases by setting so low a valuation on himself—the defect of modesty; in others by his subjection to a lofty ideal and his reprehensible indifference to every-day matters; and in many cases because his career and environment are apt to unfit him for the task of seeing that he gets his rights at the hands of the more business-like section of the community, who are not prone to turn down a good bargain when it comes their way. The scientist is not organized and does nothing to protect his corporate interests. His adopted motto might well be "faith, hope and charity"—faith in himself and his results, hope for discoveries and, lastly, enough charity to help him in the meantime to keep body and soul together.

But every dog has his day, and the country in its hour of need has turned to its scientific sons for help in its war problems, and has not turned in vain. The war is bringing home to the nation the dependence of its very existence on science; and a little good may come out of a very great evil if public opinion can be brought to realize that the statement is as true in peace as in war, and that a nation's administrators should always include among them suitable men of the highest technical and scientific standing, not merely to advise, but also to initiate and direct.

It will be fresh in the minds of most of us that in the early days of the war the late Sir William Ramsay spent the last few months of his brilliant life in vainly trying to convince the Government that linseed oil came from linseed and that cotton was of the greatest importance in the manufacture of high explosives; and that both commodities should be stopped to Germany by our blockade.

I have not the faintest knowledge of the inside official history of the case, but I have amused myself by imagining that what happened was that the astounded but still incredulous Government turned on its intelligence department full blast and discovered that Ramsay was a chemist. Having confirmed this by the happy thought of consulting a "Who's Who," they promptly concluded that he was the proprietor of a prosperous concern—probably in the West End—which displayed in its windows large bottles full of coloured liquids. This settled, they decided that they could safely ignore the embarrassing information under the Defence of the Realm Act. The highly placed official concerned having wiped his fevered brow then promptly put in for a month's leave, which the harrassed Government department, now on thoroughly familiar ground, granted, and put him in the next Honours List. It is all fanciful, of course, and would be amusing if it were not tragical.

In America they have not sought to starve science—quite the reverse—and, to take our subject of to-night, it has to be admitted that it is to America that we owe almost all the great improvements that have been made of recent years in the technique of X-ray production. Consider the Coolidge tube, for example, and

again the apparatus devised by Hull in the General Electric Laboratories at Schenectady, which supplies a steady current of a milliampère at a constant potential of over 100,000 volts. The cost—£1,000—of such an installation would have paralysed any British Board of Directors audacious enough to have toyed with the idea. Let us hope the new Department of Scientific and Industrial Research will succeed in changing the atmosphere of suspicion with which the average British manufacturer greets anything which does not promise an immediate return for his outlay.

And this leads me to say a word on the future of the British X-ray industry, a subject to which we devoted several meetings last session. Just now the X-ray manufacturer is tasting prosperity, but the prospect after the war is, to my mind, none of the rosiest. The hall-mark of success may be efficiency, and patriotism may lead us to support home industries, but hard times are ahead, and I would earnestly draw the attention of the industry to the well-established fact that both for capital and labour the day of small and disconnected enterprises is done. Effective organization will have to be conceived and carried out on a larger scale. Cognate enterprises will have to learn the value of association, for only a great concern can afford to retain highly technical men, to maintain the necessary research laboratories and, above all, to offer to its workers remuneration, advancement and pensions on a scale which will ensure efficient and faithful service untrammelled by petty financial cares. It is on co-operative lines that the present industrial unrest of the workers of to-day will be settled.

However, "Beama" is an excellent beginning, to be seconded, I hope, by the Advisory Committee, recently initiated by this Society; but "Heaven helps those who help themselves," and I should like to see the various X-ray concerns of this country band themselves together with the closest ties, after the fashion of the X-ray corporation recently formed in the States. The race is to the swift and the Hun will take the hindmost.

We all regret that circumstances over which we have no control have led to the exhibition of all-British apparatus being somewhat curtailed this evening. We hope that the enterprise of the British manufacturers will find it possible later in the session to rise to the occasion and seize the valuable opportunity of displaying their wares before the Society's members and friends.

And now my task draws to its close. I foresee a glowing future for our Society. Our membership is steadily increasing and our financial position is sound, but we need a large increase in our membership to augment our usefulness and to give us the acknowledged authority and prestige to which we have the right to aspire. Our finances should be such as to enable us, among other things, to extend the scope of our Journal, and to encourage research by substantial grants.

The Council needs the earnest co-operation of the members of this Society to invite to membership any of their friends with suitable qualifications. Radiologists, radiographers, physicists, chemists, electrical engineers and manufacturers, we want them all to join us and come and talk over their difficulties at our meetings.

I hope some day to see in London a Central Institute of Radiology, administered by this Society which would there find a permanent home after its wanderings. Such an institution, fitted with laboratories, library, lecture hall and a real "live" museum of apparatus, would be the headquarters of the British School of Radiology. With the continual co-operation of the manufacturer, its equipment would always be the very last word. Its functions would be dual, the one to carry out radiological

research in its own laboratories, the other to conduct courses of lectures in radiology by its own staff and those of related institutions, and, also, from time to time by distinguished radiologists from abroad who would be attracted by the opportunity to see something of British radiology—second to none in the world both in its technique and in its clean traditions—even if it has not learnt to advertise. Such lectures, both clinical and technical, could well form part of the graduate or post-graduate courses of the University medical schools. By such means we could attract a great many men who formerly went to Germany for inspiration and instruction and also encourage the closest relations between ourselves and the French and American schools of radiology, the initial steps of which I should like to see taken at once. We have already received the friendliest overtures from both the French and Americans, and an effective association of the Allied schools would be more than equal to the German school.

I am glad to say that the first steps towards such an institute have been taken and it only needs enthusiasm and financial backing to produce a worthy memorial of the part radiology has played in the war.

This Society now exercises its influence over a field of interest which has expanded completely beyond the ideas of its founders, who, in their choice of name, never contemplated such an extension of its activities. There are many in the Society who hold the view that a more comprehensive title would be to its advantage.

Adequately housed and appropriately designated, with its various sections continuing to co-operate for the better advancement and dispersion of knowledge, the Röntgen Society will take no mean place among the learned societies which have rejoiced in being able to render signal service to their country.

At the conclusion of the address, a vote of thanks was proposed by Sir James Mackenzie Davidson, who referred to the early activities of the Society and to the researches of the President that had added greatly to our knowledge of the physics of the X-ray. The vote was seconded by Dr. F. W. Metcalfe and was passed by acclamation.

EXAMINATION OF METALS BY X-RAYS.

By MONS. H. PILON.

A number of radiographs were exhibited illustrating the application of X-rays to the examination of metals by means of Coolidge tubes and specially designed apparatus. The first example demonstrated the faulty welding of an iron tank, with metal ten millimetres in thickness, the distance between the plate and the anti-cathode was 125 centimetres and the rays had passed through two sides of the vessel, making 20 millimetres thickness of iron. Another example showed a fault in the aluminium gear case of an aircraft engine, air holes in the metal had been filled with an alloy of greater density. Another example revealed faults occurring in two bars of brass each 15 millimetres in thickness, and a section of an iron bar having a nickel core gave radiographs of different densities indicating the difference in the atomic weights of the two metals. The results of X-ray exposures through scales of lead, copper and tin, of increasing thickness were also shown, lead of 5 millimetres and tin of 12 millimetres having been penetrated, using a current of 3 milliampères with an alternate spark gap of 25 centimetres.

The examples shown on Plate I. are from Mons. Pilon's photographs.

EXHIBITION.

An exhibition of apparatus and radiographs was open in the Society's meeting-room after the formal proceedings were concluded. Only the restricted character of the accommodation prevented a larger exhibition being held. A good collection of radiographs was shown by Major R. W. A. Salmond, Major Stowe, and Dr. Martin Berry. A Wheatstone stereoscope as made for the Army, and embodying the most flexible mechanism for the insertion of any size of plate, was exhibited by Mr. A. E. Dean; Messrs. Ilford, Ltd., showed a number of stereoscopic radiographs by Dr. Gilbert Scott in a Wheatstone stereoscope. The Ilford firm also showed some results on their X-ray plates, combined with the use of an intensifying screen, as produced by Mr. W. R. Coldwell. Some results with the Wellington X-ray plate were also on view, and there were a number of photographs to illustrate war injuries to the face and their repair, as described by the President in the course of his address. Some spectroscopic illustrations of tungsten and iron spectra and some plates showing the germicidal action of ultra-violet radiation were exhibited by Dr. W. M. Kingsbury and Dr. Russ, of the Middlesex Hospital. Dr. Fournier d'Albe showed some high-resistance graphite as used in his optophone. A new and smaller model of the Coolidge tube, giving very sharp focus, was sent by the British Thomson-Houston Co., Ltd. In the vestibule Sir James Mackenzie Davidson's latest pattern X-ray couch attracted a great deal of attention. This couch is so devised as to enable localisation to be carried out on the well-known principle, automatically and without calculation, within a very few seconds for each case, by means of a properly calibrated recording mechanism.

SESSION TWENTY, 1917-1918.

ORDINARY MEETING, held at the rooms of the Royal Society of Arts, John Street, Adelphi, on December 19th, 1917. Ballot, see page 31. Papers by **Professor J. W. NICHOLSON** and **CHARLES A. SCHUNCK.**

ABSORPTION SPECTRA OF X-RAYS.

By Professor J. W. NICHOLSON, M.A., D.Sc., F.R.S.

My object to-night is not really to give a paper—for my remarks do not involve any work I have done myself,—but rather to acquaint you with what M. de Broglie has done in France during thelast eighteen months and which is more or less inaccessible to English readers. Some of it has been published in the *Journal de Physique*, but I can only discover that one copy of that journal is in this country. I thought, therefore, that it would be interesting if I obtained an account of M. de Broglie's work for the Society. M. de Broglie was in England recently, and gave me some lantern slides, promising me some more, but as he has since gained distinction in the work of detecting U-boats, I cannot be surprised that the others have not arrived.

During the time I have been associated with the Society I have not, so far as I can remember, heard any paper in which we were actually presented with photographs of X-ray spectra, and that, in a way, is rather a serious deficiency. So long

as that is the case we are bound to talk of the absorption of bodies for X-rays in rather general terms, and not speak of absorption in terms of particular wave-lengths. The kind of absorption which takes place in a body on which X-rays fall is well known. If we were to plot a curve of absorption against increasing wave-length it would take the shape shown in Fig. 1, and it would have two points which were quite definite maxima of absorption corresponding to particular wave-lengths. The first belongs to the ordinary K radiation, and the second the L radiation. One of the characteristics of these radiations is that while the first point (corresponding to the K radiation) is sharp, the second point (corresponding to the L radiation) is very much rounded in comparison. What we call penetrating power is simply a question of wave-lengths as apart from these two particular wave-lengths. Superposed upon what we may call the normal absorption of bodies—that is to say, an absorption which increases regularly with the wave length without these maxima, there is a selective absorption, and it is this selective absorption which we call the absorption spectrum for the particular absorber used for transmission of the X radiation.

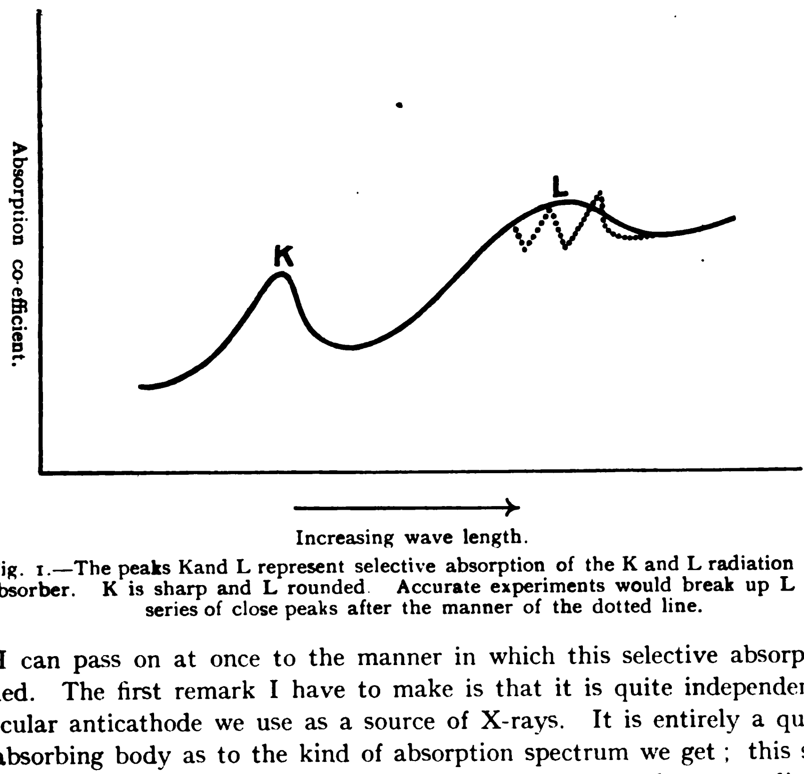

Fig. 1.—The peaks Kand L represent selective absorption of the K and L radiation of the absorber. K is sharp and L rounded. Accurate experiments would break up L into a series of close peaks after the manner of the dotted line.

I can pass on at once to the manner in which this selective absorption was studied. The first remark I have to make is that it is quite independent of the particular anticathode we use as a source of X-rays. It is entirely a question of the absorbing body as to the kind of absorption spectrum we get ; this spectrum depends on a characteristic property of that body just as much as an ordinary light spectrum betrays the characteristic of the body which is emitting or absorbing the light. The photographs I shall show presently involve two quite distinct phenomena under this head. Into the details of the apparatus I do not propose to enter ; it is practically identical with that used in optical experiments. The rays are generated and are then separated off into a spectrum by a crystal which acts like a diffraction grating, and we get a spectrum of the radiation which is projected on to

a photographic plate, so that, as we look along the plate, we get the sequence of effects produced by the various wave-lengths.

The first phenomenon of the two I shall mention is the action of the photographic plate itself. The elements of importance present on that plate are silver and bromine, and certain wave-lengths which are peculiar to or characteristic of silver and bromine—the K radiations peculiar to these elements—stimulate the atoms of silver and bromine present there, electrons are shot off, and these accelerate any chemical action which would ordinarily take place, so that there is an impression produced on the plate in the positions corresponding to the K radiations of silver and of bromine. These impressions are actual bands or patches which stop sharply on one side—the side corresponding to greatest wave-length—and gradually on the other, with the result that on the plate we get a dark band becoming less and less dark as we go towards the centre from the end of maximum blackness. It follows, then, that the characteristic radiations of the elements present on the plate, which are in fact these two, produce two dark bands; but only the silver one is important for our purpose, because the bromine band is not shown with any strength on most of the negatives.

Now for the second phenomenon: suppose we interpose in the path of this radiation any element capable of absorbing characteristic rays, and that we have a radiation which contains the characteristic radiation for the sheet of metal which we interpose in the path of the radiation before or after it is treated by the crystal. By so doing we remove that radiation from what ultimately makes the photographic effect. It is absorbed particularly near K and L, and is absent from the final radiation which strikes the plate. It follows that instead of the plate being affected to some extent all the way, and heavily affected in the sense of being made dark, certain radiations are not there at all, or only to a very inappreciable extent in comparison with others, and they constitute, taken together, the actual absorption spectrum of whatever we interpose. If absent, then the positions on the plate where these normally come are not darkened at all. The portion of the blackened plate due to the silver radiation is not, for example, blackened if the interposed element causes a light patch which completely covers the patch due to silver; the particular wave-lengths which would blacken that portion are removed, so that we get a light patch. The joint effect of the absorbing substance and the silver may, on the other hand, produce a dark band.

For we have to consider certain different cases. The K radiations of an element are known to follow a perfectly regular law which was discovered by Moseley, and some time ago Mr. Bragg gave a very full account to this Society of this particular phenomenon. If the atomic weight of the element is smaller than the atomic weight of silver, the K radiation has a longer wave-length than the corresponding K radiation of the silver, and the dark silver patch is obliterated. As an example of an element which is heavier than silver we will take antimony. In the case of antimony the effect we get apparently is that of a black band followed by a light patch towards the centre; actually it is the superposition of a light patch due to the stoppage of the characteristic antimony radiation added to the silver radiation which has not been stopped. This patch gets narrower and narrower as the atomic weight of the element approaches that of silver. If it is below that of silver, the dark patch is quite wiped out, and we get the first case considered.

Now as regards the details of this method there is perhaps one about which I

should make a remark. It relates to the manner in which absorbers were interposed in the path of the radiation. In the case of the metals very thin sheets were used for the radiation to pass through, usually about 1/100th mm. in thickness. In the case of compounds sheets of paper were painted over with the compounds, and it was not difficult to discover how many of these sheets of paper were necessary to give a really pronounced final effect on the plate. The most interesting thing to physicists in connection with the photographs concerns the exact wave-lengths of the heads of the bands—the places where they suddenly stop on the side of long wave-length. These can be determined quite easily by the angles of reflection from the crystal to which they correspond. In the case of interposed copper the angle was as much as 14° 15′; in silver it was 4° 53′; antimony, which is very nearly the same in atomic weight, gives us a narrower angle, namely, 4° 3½′ and so

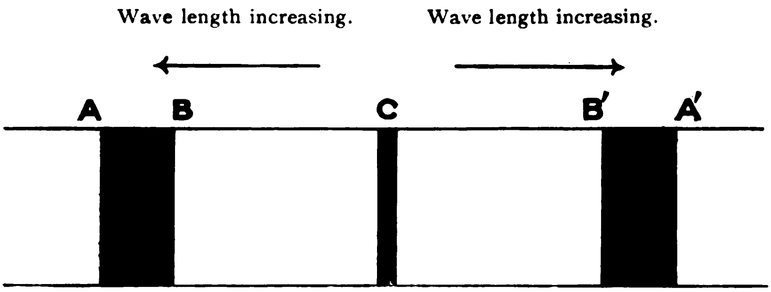

Fig. 2.—Structure of the K absorption band of an element heavier than silver.
C = Centre of pattern, corresponding to zero wave length on either side.
A, A′ = Sharp edges of dark silver bands stretching inwards towards C.
B, B′ = Sharp edges of light bands of element stretching inwards and obliterating the silver band.
The two halves of the pattern are identical.

on right down to bismuth, which gives 1° 20′. These can be measured with very great accuracy, and it is possible to determine quite easily from the measurements of these angles what the extreme wave-length of the absorption band actually is, and it exactly corresponds with the ordinary emission band of the absorbing substance. This is another step towards establishing the essential identity of X-rays and ordinary light in every respect except in the order of magnitude of the wave-length, in which there is a complete difference. It is also another step forwards in proving that these radiations are characteristic of the particular element in question, for M. de Broglie has taken various compounds of elements and made some interesting experiments. He has examined, for instance, and actually superposed the X-ray spectra of iodine, potassium iodide and lead iodide, and has found that the iodine band is obtained in the same position from every one of these three, so that in sending out the characteristic radiation, the iodine does act simply as an atom of iodine as though it were not in association with anything else, and it stops or sends out its characteristic radiations and nothing more in each case.

When we come to the L radiation there is rather a difference. I have mentioned already the rounding off of that peak in the original absorption curve as compared with the sharpness of the peak representing the K radiation. This is explained quite satisfactorily by M. de Broglie's experiments. It is found that the L radiation is not so simple a radiation as K, and M. de Broglie has even gone further and determined actually the wave-lengths of which it is made up. The L absorption of a

body consists of at any rate three different components which would appear as shorter light bands on this plate. They practically give the effect of a single band. There are, however, places where the shading is not equally complete, and we get a confused looking jumble as the combined representation. The rounding off of the absorption peak is merely due to experiments which are not very sensitive, and if the curve were obtained properly we should get sharp ups and downs in the line representing the absorption. I have not any photographs which show the L radiation at all well; the radiation is very much weaker than the K, and requires a very much longer exposure to bring it out at all.

The first slide shows us the absorption spectrum we get by the interposition of a thin sheet of antimony. The silver band by itself would be a dark band beginning sharply at one end and extending practically to the centre. It becomes invisible before the centre merely through insufficient exposure. Antimony has a shorter wave-length and starts as a light band nearer to the centre. The breadth of the composite dark band, where there is no overlapping, gives an idea of the relative approach of the atomic weights of the two bodies. The next slide illustrates, in the upper part of it, tellurium, and in the lower part iodine. The atomic weights of tellurium and iodine are both of them greater than that of silver, and it will be noticed that the beginning of the bright portion of the iodine image is not very far removed from the beginning of the tellurium. They do not quite coincide, but very nearly. This slide is particularly interesting, because it shows how easy it is—although it is not so easy from an atomic weight point of view—by using the spectra of X-rays, to distinguish two elements whose atomic weights are nearly equal.' In Bragg's paper before this Society that was pointed out before very clearly, but the interesting part of this slide is that, while it is well-known that tellurium and iodine are rather an anomaly in the periodic table, because the wrong one comes first from the point of view of atomic weight, the image of the photographic spectra puts the matter right, and the element with the bigger atomic weight actually gives a radiation of greater wave-length, so that the significant thing is evidently what Mr. Moseley called the atomic number, the theory of which I need not repeat to-night. This slide, then, puts the order of the periodic table right, indicates the difference we do get in the K absorption band, corresponding to one step in atomic number, and gives thereby an idea of the degree of accuracy with which the actual wave-length itself can be measured.

The third example is the case of cadmium, which only differs from antimony in the fact that its atomic weight is very much nearer to the atomic weight of silver, and correspondingly we get an extremely thin dark band. In the next example we have strontium, in which the silver band is completely blotted out. The atomic weight of strontium is small compared with that of silver. In the case of strontium light one starts almost at the end of the photograph, and completely covers it over with a light band superposed on a slightly darker background. That is all we can get with strontium. The next example shows us uranium and thorium. I really incorporated it in the series in order to show the absolute identity of the position of the silver band with whatever other substance it is associated. The head of the silver band is in exactly the same position in the two cases. It is one continuous line all the way up, and in the L radiation of uranium and thorium, we see obviously several different beginnings of bands at various points, though these do not corre-

spond, being all a little shifted in one element from the positions they occupy in the other.

The next and last example shows the general spectrum of tungsten mixed with a variety of other things. I do not propose to pick out what any particular thing is in this instance, but the real object of the slide is to show the average kind of spectrum one can get with X-rays by this method, and to bring out the fact that the positions of everything are quite as pronounced in X-ray spectra, as shown in this work of M. de Broglie, as they are in the ordinary spectra of visible light. This last example is not at all unlike an ordinary visible light spectrum—in fact, at first sight I should be inclined to think it was an ordinary spectrum in the region of visible light. One of the photographic prints will illustrate a further point—namely, the identity of the iodine spectrum. You will see there the spectrum from iodine, potassium iodide and lead iodide, and I do not think anyone will be able to detect any difference whatever in these three sub-divisions of the photograph, as regards the position of the K radiation of iodine.

DISCUSSION.

Mr. W. F. HIGGINS: There is just one point of interest which relates to the similarity in absorption between ordinary light and Röntgen rays, and this is illustrated in the iodine example. In the case of ordinary light the iodine shows a brilliant coloured spectrum, potassium iodide is practically transparent, and lead iodide opaque. This is a purely molecular and not atomic action in the case of ordinary light. It is a further confirmation of the fact that the wave-length of Röntgen rays is much smaller than or the radiations composing ordinary light.

Mr. E. A. OWEN: In some experiments on X-ray spectra which I have recently been carrying out, I find that the crystal used for the reflection of the rays has a very appreciable effect upon the form of the spectrum of the rays emitted by a given bulb. Professor Bragg has shown that when an X-ray which excites the characteristic radiation of an atom in the crystal used for the reflection of the X-ray, the selective absorption of the ray in the crystal shows itself in a reduced intensity of that particular wave-length in the spectrum. This phenomenon can be utilized to investigate the J-series of the light elements, discovered by Professor Barkla. In the case that I have been investigating, rays from a palladium anticathode fell on a crystal of carborundum, which is composed of the two elements carbon and silicon. In the spectrum obtained a minimum of intensity occurred invariably at the same wave-length, indicating selective absorption of this wave-length by the crystal. Different considerations led one to assign the value of the wave-length when the minimum occurred, to the β wave of the J-series of Silicon, and the value agrees closely with that deduced from Barkla's results by the ionization method. I have not had time to go into the matter thoroughly as yet, but this line of investigation promises interesting results. I should like to know what opinion Professor Nicholson has formed with regard to the J-series of the elements.

Professor NICHOLSON said in reply: I must thank Mr. Higgins in the first place for bringing out another point which these photographs show. I am very glad it struck him —the fact that it is entirely an atomic phenomenon which we are dealing with in the case of X-rays, and that this does constitute another evidence of the extreme smallness of the wave-length of the rays. The wave-length of the

X-rays is practically of the same magnitude as the radius of an atom, so that we are entitled to draw the deduction that an atom in combination should give its own spectrum. Mr. Owen introduces some interesting points on which I am not able to give any opinion to which I should like to be bound. With regard to the use of crystals, M. de Broglie used the same crystal throughout his experiments, and makes no reference to any possible difference in effect by using another crystal. At the same time, I do not see why there should not be this selective effect of the crystal. With regard to the J series, Mr. Owen is trying to draw me into expressing theoretical views, in a region where guiding principles are rare at present. I see no reason why there should not be a J series, and possibly even a fairly strong series, and all I can do is to express the hope that Mr. Owen will soon have enough time to be able to attack the question again and come to a definite conclusion. If I am to express an opinion for which I cannot hold myself absolutely responsible, I would say that there might quite conceivably be such a series, from certain analogies in visible light. In conclusion, I thank the Society for the attention it has given to me on the subject. I take it as a sign that my action in persuading M. de Broglie that the Society would like to hear about his work is thereby commended.

THE REGION OF THE ULTRA-VIOLET SPECTRUM OF GREATEST THERAPEUTICAL EFFECT.

By CHARLES A. SCHUNCK, F.C.S.

In a previous paper to the Society* upon sources of ultra-violet radiations in relation to treatment by ultra-violet rays, I came to the conclusion that the radiations of greatest therapeutic value lie between λ 3000, near the limit of the solar spectrum at λ 2930, and λ 1850, the limit due to strong atmospheric absorption even in thicknesses of a few centimetres, the ultra-violet spectrum extending from about λ 3900 to λ 1850. Experiments have since been made in the endeavour to ascertain which are the most effective radiations therapeutically in this region as judged by the erythema produced on the skin which medical opinion considers measures the clinical efficiency of the radiations in question. By protecting the skin when exposed to the tungsten arc, with a one mm. thickness of glass which absorbs all radiations shorter than λ 2950, it was shown that no reaction took place, whereas with a piece of microscopic cover glass that cut off the radiations at λ 2750, there was a slight reaction in one experiment. In this manner it was arrived at that radiations above λ 3000 in the ultra-violet had no therapeutic value under the conditions in which the experiments were made. These same conditions were adhered to in the subsequent experiments, *viz.*, the source of radiations was 3¼ in. from a quartz cylindrical condenser which produced a band of light on the skin of the arm about ½ in. wide 16 in. from the condenser, the ampèrage being 8 with exposures up to five minutes with the tungsten arc. Varying thicknesses or strengths of solutions of copper sulphate causes a general end absorption in the violet and ultra-violet region of the spectrum, the rest of the spectrum being entirely transmitted.

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* *Jour. of the Röntgen Society*, vol. 13, pp. 33 to 36, 1917.

The less the thickness or weaker the solution the further the transmitted radiations extend. Taking solutions, which must be exceedingly dilute, that transmitted respectively to λλ 2900, 2800, 2750, 2650, 2600, 2500, 2450 and 2400 and exposures of two minutes with the tungsten arc at 8 amps., there was no reaction at λ 2900 a slight reaction from λ 2800 to λ 2600, and a good one from λ 2500 to λ 2400. The erythema at λ 2400 was about the same intensity as with the tungsten arc alone which was used as a control experiment, the solutions were enclosed in a glass tube with quartz ends, the length of the tube could be varied, and it was interposed between the cylindrical lens and the skin. These results show that there is an increased effect with decrease of wave-length, the maximum commencing at λ 2500, but they are open to the objection that the effect may be cumulative from λ 2900, due to the gradual increase of transmitted radiations as λ 2400 is approached. Solutions therefore of quinine sulphate, salicylic acid and phenol were prepared which, according to the researches of the late Sir N. Hartley (reference Phil. Trans. Roy. Soc., p. 257, 1879, and p. 471, 1886.) were of such strength that they transmitted respectively from λ 2950 to λ 2650, λ 2725 to λ 2500, and λ 2500 to λ 2350, there being an absorption band in each respectively from the higher values to λλ 3750, 3150, 2850, so that all radiations longer than these are transmitted. Since it was ascertained that radiations above λ 2950 produce no erythema, by utilizing these solutions as absorbants one can examine the effect of the radiations transmitted, though lessened in intensity compared to the same in the tungsten arc, by the three regions indicated between λλ 2950 and 2350 independently (Plate I., Fig. A). In one experiment an exposure of four minutes with 8 amps. was given through these three solutions, also an exposure through 1 mm. glass and one with the arc alone, with the result that only a slight reaction compared to the arc alone was obtained with the phenol, which transmitted λ 2500 to λ 2350 and λ 2850 and upwards, so almost all the effective radiations were contained between the lower values. In another experiment a piece of cover-glass transmitting to λ 2750 was substituted for the quinine solution, five minutes' exposure being given to get an increased effect, with the result that an erythema not so intense as with the arc alone was produced through the phenol, while through the salicylic acid and cover-glass there was only just an indication. There still remains in the phenol experiment the effective region from λ 2850 to λ 2950 to be considered. An experiment was made quite recently with the tungsten arc at 8 amps. and four minutes' exposure, as before through the (1) phenol solution, (2) the phenol solution and cover glass, (3) the cover glass alone, and (4) a piece of 1 mm. glass. In (1) there was a good final reaction of deep pink colour, in (2) and (3) a slight pink reaction and in (4) no reaction. The erythema in (2) and (3) disappeared in a couple of days, while in (1) it alone subsisted for a week, so I think one can conclude that the radiations between λ 2850 and λ 2950 did not materially add to the effect of the radiations between λ 2500 to λ 2325. The erythema in (2) was a little more intense than in (3) and the times of first indication on the skin were in (1) 1½ hrs., (2) 2½ hrs., (3) 5 hrs. after the exposures. Thus the greatest effect is produced by the radiations between λλ 2500 and 2350, and it will be noted from the plate that these are of considerably less intensity than those transmitted between λλ 2900 and 2500. The latter experiment was repeated with the iron arc (Plate I., Fig. B) with exposures of 10 minutes and 8 amps., with the result that a fair reaction was obtained through the phenol, a faint one in the case of salicylic

acid and just an indication through the cover-glass, and again it is to be noted how much less intense are the radiations transmitted by the phenol compared to those transmitted by the salicylic acid solution, where about the maximum of intensity in the iron arc occurs. Further, in the ultra-violet it is difficult to carry out experiments, for the radiations both of tungsten and iron become less intense and as λ 2000 is approached the ordinary photographic plate loses its sensitiveness due to the absorption of these short radiations by the gelatine of the plate.

So far the experiments show an increase of effectiveness with decrease of wave-length, especially from λ 2500 downwards; whether there is a distinct maximum region has still to be ascertained. From the Plate I., Fig. C, of the arc spectra of tungsten, iron, carbon and the mercury vapour lamp, the sources used therapeutically, the maximum in this region in the carbon arc is a group of lines at λ 2500, due to silicon. It may be these are the most effective radiations in this source, and I had hoped to be able to prove so, but under the same conditions that the tungsten and iron arcs were used, the carbon arc only gave a very slight erythema which precluded arriving at a definite conclusion. The mercury vapour, a Cooper Hewitt lamp of Silica glass, also gave but a slight effect under the same conditions, but only a 110-volt lamp was available, and to get the maximum ultra-violet radiations from this source a 200-volt lamp at least should, I am told by the makers, be used, and thus, what looked like an ideal spectrum of isolated, intense broad lines for the purpose of ascertaining the therapeutic effect at different parts of the ultra-violet region could not be utilized.

Major Turrell thinks that the erythema may be induced by a movement of electrons in the superficial tissues (to which the action is localized) in the form of a bombardment—an electronic effect. The emission of electrons by light causing a change in the electrical state is a photo-electrical effect. That it may be such here is supported by the results of the experiments and from the fact that in photo-electrical action the number of photo-electric electrons emitted per unit of time increases as the wave-length of the light increases, probably reaching a maximum in the extreme ultra-violet according to Compton and Richardson, and the velocity of the electrons likewise increases. Also the number of electrons emitted per unit of time is directly proportional to the intensity of the source and clinical results show that a more beneficial result is obtained with increase of ampèrage of the arc.

If this interpretation is correct, then the wave-energy absorbed by the superficial tissues is converted into the energy of the moving photo-electric electrons and that they act in such a manner as to dilate or obstruct the smaller vessels and allow the blood to escape and diffuse through the superficial tissues, which in simple language is what happens in an erythema, and in which, it is considered, lies the main curative effect.

DISCUSSION.

Mr. J. H. GARDINER asked if it would be possible to project the spectrum on the arm and note directly where the greatest action took place.

Dr. SIDNEY RUSS: I am very glad to have had an opportunity of listening to Mr. Schunck's paper, and I could not help being struck by the extreme beauty of his reproductions of the absorption spectra. He has managed to pick out just the right solutions to effect the absorption desired. But I do cross swords with him on his conclusions. I cannot agree that the region from wave-length, 2,540 down

to 2,380 Å.U., is the most effective. As far as I could gather, I rather think that Mr. Schunck has given a little too much attention to the short wave-lengths and has neglected that region between 2,880 and 2,960 Å.U. In his example in which the phenol was used, a transmission is given in the region of 2,360 up to 2,500. When Mr. Schunck makes an exposure to this radiation he states that an erythema is quickly produced, but if he interposes a 1 mm. thickness of cover glass, which does not let anything beyond say about 3,000 through, he does not get any erythema. When he puts the cover glass in front of the phenol, he cuts off this transmission band, so that he gets practically no reaction, but in so doing he also cuts off the important region between 2,960 and 2,880. If you make experiments on the way in which the tissue itself absorbs these radiations, you find that it absorbs very strongly in the region from 2,960 Å.U. down to the shorter wave-lengths. I would submit that it is still open to question whether the region 2,880-2,960 Å.U. is not equally effective in producing this erythema as that bunch of wave-lengths from 2,350 to 2,500 Å.U.

Professor NICHOLSON : There is nothing that I can usefully say in discussion of the paper. I am not competent to discuss the conclusions at issue, but I echo Dr. Russ's congratulations to Mr. Schunck on the technique of the photographs he showed us, which are among the very nicest photographs of spectra I have ever seen, particularly of absorption spectra, which are not so easy to get with such excellent definition.

Mr. W. F. HIGGINS pointed out that the active region referred to by Mr. Schunck corresponded with that found by Drs. Russ and Mottram in their work on the bactericidal action of ultra-violet light.

THE CHAIRMAN asked for information as to the strength and thickness of the solutions used as filters, and also what was the form of the cell used.

Mr. SCHUNCK : Mr. Gardiner asks whether it was possible to test the spectrum of the source on the skin. This was tried by placing the arm in the position the photographic plate occupies, but though the slit was widened considerably and an exposure of 15 minutes to the tungsten arc was given, there was no effect and the experiments in this direction were not further proceeded with. Dr. Sidney Russ considers I lay too much importance on the region from λ 2500 downward, compared to that between $\lambda\lambda$ 2950 and 2750 as to the therapeutical effect. I own the effect the latter region may have in the phenol experiment has given me a great deal of thought, and the experiment with the cover glass in addition to the phenol solution was performed during last week as additional evidence to my contention in favour of the shorter radiations being more effective. Taking all the experiments with the cover glass between the source and the skin I find it depends upon the length of exposure if one gets an effect or not. In the former series of experiments I only used exposures of two minutes with ampèrages between 8 and 10, and in only one experiment of 2½ minutes and 10 amps. did I get an effect. But in these later experiments exposures up to five minutes were given and an effect, though slight was obtained when the cover-glass was interposed but none with 1 mm. thickness of glass. When there was no effect with the cover glass there was a fair one through the phenol, and when the exposures were increased so that there was a slight effect with the former, a good erythema was produced through the latter. The effect

of the radiations from λ 2850 upwards is common to both the cover glass and phenol experiments, yet the resulting erythema in the latter is far greater than the former, which I think alone points to the fact that the region between λλ 2500 and 2350 is far more effective than that between λλ 2950 and 2750.

In reply to Dr. Rodman, whose kind remarks upon my work I much appreciate, the tube used to hold the absorbing solutions is the one designed by Prof. E. C. Baly for absorption spectrum work. It consists of two concentric glass tubes sliding into one another. The outer one is about 1 inch in diameter and 5 inches long, closed at one end in each by circular quartz plates cemented to the ends, the inner one, which just fits inside the outer one, being 10 inches long. The outer one has engraved on it a millimetre scale up to 10 centimetres and has a glass bulb which serves to fill the space between the two tubes with the solutions and to act as a reservoir. The two tubes are held together by a piece of rubber tubing, which makes a water-tight joint and allows the inner tube to slip inside the outer one, so to regulate the thickness of the liquid which is read off by the scale. This apparatus is placed between the cylindrical condenser and the skin and the image of the arc source is then a circular patch of about ¾ inch diameter. When the mm. glass and cover-glass were used they were put in front of the condenser, which measures 1 inch by 1 inch. The strength of the quinine sulphate solution was about $\frac{N}{1000}$ thickness 1 cm., the salicylic acid $\frac{N}{1000}$, 2 c.m., and the phenol $\frac{N}{100}$, 1 cm. thickness, where N is *normal strength, viz.*, the molecular weight of the substance in grams dissolved in 1 litre or 1000 grams of water, which was specially purified.

I must thank Prof. Nicholson for his very kind appreciation of the technique adopted and the spectra I have been able to show, especially as coming from one of our foremost experimenters in spectrum analysis.

OBITUARY.

WILLIAM DUDDELL.
Born, 1872; Died, 1917.

By the death of Mr. W. Duddell the Society has lost one of its most active and valuable workers. He was our President for the session 1907-8, and devoted a very great deal of time to the interest of the Society. Mr. Duddell undertook the arrangement and classification of the collection of historical X-ray tubes that are now in the Victoria and Albert Museum, and it was through his efforts that the Society found a home in the Institution of Electrical Engineers. He was rarely absent from our Council meetings, and his advice upon all matters connected with the welfare of the Society was of the greatest value. Professor Duddell's work in the electrical world is well known to us all, and need not be referred to in detail. His name will always be associated with the "oscillograph" and the "musical arc." He was one of the youngest Fellows of the Royal Society, being elected in 1907, and was awarded the Hughes Medal in 1912.

After the outbreak of the war, he became a member of the Advisory Council for the Promotion of Scientific Research, and of the Board of Inventions to the Admiralty. Recently he was created a Commander of the Order of the British Empire.

Mr. WILSON NOBLE.
Born, 1855; Died, 1917.

In the death of Mr. Wilson Noble, M.A., which took place on October 31st, 1917, the Society has lost another of its Past-Presidents, and a valuable and energetic member. Mr. Wilson Noble was a fellow of Trinity College, Cambridge, and was one of the many amateurs who in the early days of the discovery of X-rays devoted his time to the subject. He erected and fully equipped a laboratory at his residence, Barkham Manor, Wokingham, and did a great deal of useful work there. He contributed several papers to the Society, and rendered much assistance to the medical profession in the "early days." He occupied the Presidential Chair during the session 1899-1900, in succession to Dr. C. W. Mansell-Moullin. Since the war his laboratory has been brought thoroughly "up-to-date," and within a few days of his death he was actively engaged in preparing radiographs of wounded soldiers for one of the military hospitals.

Dr. JEAN CLUNET.

News of the death of Dr. Jean Clunet has recently reached us. Dr. Clunet was a pupil of Professors Marie, Babinski and Menetrier, to the last of whom we are indebted for the following appreciation.

At the outbreak of war Clunet was engaged in a medical capacity with his regiment. He was awarded the "Croix de Guerre" for his gallant conduct at the Battle of the Marne. Following this he was sent to the Dardanelles upon bacteriological investigations, thence to Corfu to continue his work among the disease-ridden army of Serbia.

Clunet was on board the "Provence" when she sank, and by his coolness and sense of duty was the means of saving a number of those on board.

With the same devotion to duty he went with a French mission to enquire into the sanitary condition of the Roumanian army after its retirement to Jassy. After overcoming the greatest difficulties, and indifferent to the strain which they entailed upon his own health, he finally fell a victim to typhus, a disease which he had fought so well on behalf of others.

With regard to Clunet's scientific work, his most important publications dealt with pathological anatomy, bacteriology and pathological neurology. In the combined work of the laboratory and the hospital, Clunet's investigating ardour and critical spirit showed at their best, revealing at the same time his splendid honesty and intellectual capacity.

Clunet's best work was done upon the subject of cancer. Among the most important of his contributions upon this subject may be cited his "Experimental Studies upon Malignant Tumours." In his book "Tumeurs Malignes," there is a mass of experimental work, containing many new facts upon the forms and varieties of tumours, the evolution of neoplastic grafts, the morphological variations of cells,

and the action of X-rays upon malignant growths. He communicated several papers to l'Association Française pour l'étude du Cancer, upon the action of X-rays upon normal and pathological tissues.

His work upon "The Experimental Production of Cancer" stands out amid his other contributions for special mention. Upon two occasions, he produced a malignant sarcoma in the rat, at a region previously selected in healthy tissue, by exposing the part selected to repeated doses of X-rays. The malignant nature of the tumour produced was proved, not only by its growth, but by histological examination and by the successful grafting of portions of the tumour into other rats. He thus achieved for the first time the experimental production of cancer, a fact of prime importance.

Clunet's industry was extraordinary and despite all the work that his military duties entailed he did not fail to communicate the results of his scientific work to learned societies, the most important being.—"La jaunisse des camps et l'epidemie de paratyphoide des Dardanelles" and "La relation des accidents nerveux émotionnels, observés chez les naufrages de la Provence," the latter being itself a proof of the sangfroid he there displayed.

Dr. Clunet was made an Honorary Corresponding Member of the Röntgen Society in 1913.

Those who had the privilege of knowing Dr. Clunet will share this appreciation of Professor Menetrier and join with him in deploring the loss of a life so full of promise of deeds to come.

NEW MEMBERS ELECTED BY BALLOT.

Name.	*Proposer.*	*Seconder.*	*Date of Election.*
J. A. SHORTEN, B.A., M.B., I.M.S., War Hospital, Colaba, Bombay ...	Sidney Russ	Robert Knox ...	Nov. 6th, 1917
DUNCAN OTTO MACGREGOR, M.B., C.M. Medical Superintendent, Victoria Hospital, Glasgow. Address: Langside Cottages, Langside, Glasgow	Robert Knox	Geoffrey Pearce...	Nov. 6th, 1917
LADY CONSTANCE MARY BUTLER, 32, Upper Brook Street, London, W.1	Howard Humphris	W. Hampson ...	Nov. 6th, 1917
DR. CLAUDE SABERTON, Spring Mount, Springfield Avenue, Harrogate ...	C. Thurstan Holland	Robert Knox ...	Nov. 6th, 1917
DR. E. ERASMUS ELLIS, 46, High Street, Beira, Johannesburg, South Africa	Geoffrey Pearce ...	Robert Knox ...	Nov. 6th, 1917
W. CARRICK ALLAN, M.D., Senior Medical Officer, Hackney Infirmary, Homerton, E.9	Arthur Schiff	J. H. Gardiner ...	Nov. 6th, 1917
ERNEST WM. REED, M.B., B.Ch., Captain, R.A.M.C., 4th London General Hospital, Denmark Hill, S.E.5	Robert Knox	G. H. Rodman ...	Nov. 6th, 1917
JOHN A. E. LYNHAM, B.A., M.D., Radiologist, Radium Institute, Riding House Street, W.1 ...	Robert Knox	Sidney Russ ...	Nov. 6th, 1917
A. M. GEDDES, Glencairn, Grove Avenue, Claremont, Cape Colony, S. Africa	Howard C. Head ...	James Metcalfe ...	Dec. 19th, 1917
MISS E. M. MAGILL, M.B., B.S.Lond., Endell Street Hospital, Endell Street, London, W.C.2	Sidney Russ	Robert Knox ...	Dec. 19th, 1917
JOHN THOMAS LEES, 19, Bromley Road, St. Annes-on-Sea	David Lawson... ...	Geoffrey Pearce...	Dec. 19th, 1917
DR. FRED WEBER, New York Mutual Buildings, Cape Town, South Africa	J. Stephen V. d. Lingen	J. H. Gardiner ...	Dec. 19th, 1917
HENRY N. JOHNSTON, M.B., F.R.C.S., Medical Officer in Charge of Electrical Dept., The Queen's Hospital, Sidcup, Kent	Robert Knox	E. S. Worrall ...	Dec. 19th, 1917
CAPTAIN KELSLEY, Medical Officer in Charge of Dental Dept., The Queen's Hospital, Sidcup, Kent ...	Robert Knox	E. S. Worrall ...	Dec. 19th, 1917
J. ALLEN LONGLEY, M.B., Ch.B., F.R.C.S., Strathbearne, Saltburn, Yorks.	Leo. A. Rowden ...	Robert Knox ...	Dec. 19th, 1917
CHARLES HITCHCOCK, M.R.C.S., L.R.C.P., Officers' Quarters, British Red Cross Hospital, Netley ...	Robert Knox	G. B. Batten ...	Dec. 19th, 1917
WILFRED CURTIS, M.D., C.A.M.C., No. 14, Canadian General Hospital, Eastbourne...	A. Howard Pirie ...	Robert Knox ...	Dec. 19th, 1917
JOHN HENRY CONKLIN, M.D., C.A.M.C., No. 11 Canadian General Hospital, Shorncliffe	A. Howard Pirie ...	Robert Knox ...	Dec. 19th, 1917
JOSEPH WILBERT WARREN, M.D., C.A.M.C., No. 11 Canadian General Hospital, Shorncliffe ...	A. Howard Pirie ...	Robert Knox ...	Dec. 19th, 1917
JEREMIAH SIMPSON CLARK, M.D., B.A., C.A.M.C., No. 11 Canadian General Hospital, Shorncliffe ...	A. Howard Pirie ...	Robert Knox ...	Dec. 19th, 1917
PERCIVAL TEMPLETON CRYMBLE, M.B., B.Ch., R.U.I., F.R.C.S.Eng., 7, Upper Crescent, Belfast	Robert Knox	Charles A. Clarke	Dec. 19th, 1917
JOHN COMRIE, M.D., F.R.C.P.Ed., 25, Manor Place, Edinburgh... ...	Robert Knox	Sidney Russ ...	Dec. 19th, 1917
CAPTAIN WILFRED BITTINGSLEY DIGHT, University Club, Castlereagh Street, Sydney, N.S.W.	Geoffrey Pearce ...	Robert Knox ...	Dec. 19th, 1917

NEW BOOKS.

Radiography and Radio-therapeutics. By ROBERT KNOX, M.D. (Edin.), M.R.C.S. (Eng.), L.R.C.P. (Lond.). Second Edition. Vol. I., Radiography. Price 30/- nett.

We are pleased to find that in spite of the agitation caused by the war, and the amount of work crowded upon the author by military duties, he has found time to prepare the second edition of this important work; much new matter has been added and many illustrations, which now number 323. The half-tone plates are certainly the finest collection we have ever seen published.

In order to keep the book a convenient size for reading and reference, it has been considered advisable to issue the work in two separate volumes. Vol. I., *Radiography*, deals with general principles, forms of apparatus and method of manipulation, technique of application and diagnosis. These chapters have all been considerably extended, and a very full description of stereoscopic radiography has been given. One new section of immediate interest deals with Radiography in War-time, and another describes the appearances of Gas in the Tissues. The chapters dealing with the examination of the Thorax and of the Alimentary System are each considerably enlarged and illustrated with many new radiographs and diagrams.

The value of this work at the present time, when so many thousands of new workers are perforce entering upon the practice of radiology, cannot well be over estimated, and the publishers' announcement that the book has been adopted by the U.S. Army and Navy Medical Departments is a source of considerable satisfaction.

The book will be added to the library of the Society.

The *Sunic Record* for January is full of interest, the opening article, " The Birth of an Induction Coil," gives illustrated details of the winding of jointless sections and the building of the modern coil; there is a chapter on Dangers in the Röntgen Laboratory, quoting the precautions suggested by J. S. Shearer, of America, and reproducing the recommendations of the Röntgen Society that were published in 1915; useful hints for the photographic manipulation of the X-ray plate and other details are given.

We have received for review a small book entitled " The Cause, Prevention and Treatment of Cancer and other Diseases," by Lt.-Col. William Hatton Hilderbrand, late Indian Army (retired).

The title is naturally striking and upon reading the book we must admit a little hesitancy to accept all the statements made, the author contends that *cancer is caused by radium which gets into our bodies principally from drinking water*, and a few pages later on in the book, where the action of hard water and air upon lead pipes is discussed, it is stated that salts of lead, zinc, etc., are formed and that some of this lead becomes *so-called transmuted* into radium. We are unable to go over in detail the arguments and suggestions made in this remarkable work; the author appears to have a controversy both with the medical and physical professions and he advocates the appointment of an *impartial Royal Commission* to investigate the cause and prevention of cancer. The editor will be pleased to forward the book to any who are interested in the subject; it can be obtained from Messrs. Smith & Sons' shops and bookstalls, price 2/6 nett.

NOTES AND ABSTRACTS.

Messrs. Elliott & Sons, Limited, the makers of the " Barnet " X-ray Plate, have issued a small booklet dealing with the use of their plates. Following an introductory chapter, details are given for judging the condition of the X ray tube, the use of the Intensifying Screen, and an outline of the principle of Localisation, concluding with photographic methods for the manipulation of the plate. The striking feature of the booklet is the inclusion of eight very excellent half-tone reproductions of radiographs, chiefly war injuries. The booklet is sent free to anyone interested, on application.

The address delivered by Alan A. Campbell Swinton at the opening meeting of the 164th session of the Royal Society of Arts in November was characteristic of its author; the title "Science and its Functions " indicates a fairly wide subject and one is not surprised to find that the author starts with Primitive man and his " poor relation the monkey," and carries one through the civilizations of the Chaldeans, Egyptians, Greeks, down to modern days and the idiosyncrasies of the British Government. The address is well worth reading and can be found in the Journal of the Royal Society of Arts; we quote the following selected from the many interesting paragraphs:—" The case of some of the world's greatest inventors is also interesting. James Watt began life as a mathematical instrument maker. George Stephenson was a colliery fireman, who only learnt reading, writing and arithmetic after he was grown up. Arkwright, the great inventor of cotton-spinning machinery, was a barber. Daguerre, one of the principal inventors of photography, a scene painter. Sturgeon, the inventor of the electro-magnet, was a private soldier, and carried out his earlier experiments within barrack walls. Morse, of telegraphic instrument and code fame, was a painter and sculptor. Alexander Graham Bell, the inventor of the telephone, a teacher of the deaf and dumb. David Hughes, the inventor of the type-printing telegraph and of the microphone, a professor of music. Edison, a railway newsboy, practically self-taught. William, afterwards Lord, Armstrong, the inventor of hydraulic power distribution, and celebrated for his gun, was a practising solicitor till he was thirty-five years of age."

PHOTOGRAPHIC PAPER FOR X-RAY NEGATIVES.

MESSRS. THOMAS ILLINGWORTH & CO., LTD., have introduced a new series of sensitive papers specially prepared for X-ray work. As is now generally known the detail of an X-ray negative differs considerably from an ordinary "light" picture, and the preparation of a satisfactory print from the former that will faithfully reproduce the gradations of tone seen in the negative is no easy matter. Radiographers will welcome the efforts of the manufacturers to meet their needs.

Two kinds of paper have been prepared, one a fast "Bromide" and the other a slow so-called "Gaslight" paper, each of these is made in two grades, one suitable for negatives of normal density, and the other for use with weak thin negatives. All the papers are prepared with a "glossy" surface, and they appear to have a generous coating of silver. We have had the opportunity of testing the material and find that it is easy to get clean brilliant prints showing fine detail with pure whites. The makers state that the paper can be developed with Johnson's X ray plate developer, as this appears to be in general use in most hospitals. We have used the ordinary "Amidol" solution with very satisfactory results indeed; squeegeed on to a ferrotype plate the prints leave very little to be desired. All four grades are made on "Cardette" paper, which is convenient if the prints are not to be mounted.

WE understand that the complete radiographic installation of the late Mr. Wilson Noble is to be disposed of; particulars can be obtained by application to the Hon. Editor.

ABSTRACTS.

A short paper by L. A. Welo in the *Physical Review* for Nov., 1917, gives results of a spectroscopic investigation of the absorption of mercury vapour by tin-cadmium alloy. It is shown that a tube not exceeding 50 cms. in length packed with chips of an alloy of two parts of tin and one part of cadmium is an effective bar to the passage of mercury vapour from a pump to the vessel to be exhausted and may be used for this purpose in the place of the usual liquid air trap.

The Parallel Jet High Vacuum Pump. W. W. CRAWFORD, Phys. Rev. Ser. 2, vol. 10, pp. 557-563, Nov., 1917.—Langmuir's mercury vapour pump (see Journ. Rönt. Soc., vol. 13, p. 23, Jan., 1917), is modified so that the vapour molecules move in parallel directions with nearly equal velocities, thus reducing the probability of collision between these molecules and thereby increasing the efficiency of the pump. This is accomplished by the provision of a divergent nozzle through which the mercury vapour escapes into the gas entrainment space. Tests on the pump show that it is more rapid than the Langmuir condensation pump of equal size and in addition it has the advantage that water cooling is quite unnecessary. On the other hand, the construction is more complex and the exact shape of the nozzle probably has considerable influence on the speed of working. W. F. H.

Determination of the Efficiency of Production of X-Rays. P. T. WEEKS, Phys. Rev. Ser. 2, vol. 10, pp. 564-574, Nov., 1917.—The energy of the X rays emitted from a Coolidge tube was determined by means of a bolometer. The grid employed was constructed of lead of such thickness that the incident radiation was completely absorbed. The total energy supplied to the tube was measured by immersing the tube in an oil bath and noting its rate of rise of temperature; due allowance was made for the heat emission of the hot cathode. An electrostatic voltmeter, calibrated by means of a spark-gap was employed to determine the potential on the tube. The efficiency was found to vary between 0·00058 and 0·0019 for potentials on the tube of from 28,000 to 54,000 volts. The values obtained are higher than those of earlier investigations and a discussion of these is given. It is pointed out that ionization methods give a particularly low estimate of the efficiency. W. F. H.

The Germicidal Action of Ultra-Violet Radiation and its Correlation with Selective Absorption. C. H. BROWNING, M.D., D.P.H., and S. RUSS, D.Sc. (Proc. Royal Society, Ser. B., Vol. 90, pp. 33-38, 1917).—The variation of germicidal action with the wave-length of ultra-violet light was determined by a new method. This consists in photographing the ultra-violet spectrum produced by a tungsten arc in conjunction with a quartz spectrograph, on gelatine or agar plates inoculated with micro-organisms instead of on an ordinary photographic plate. After suitable exposure these plates are incubated and the action of the radiation is thereby rendered visible, those parts affected by the radiation remaining transparent while on the remaining parts a copious growth of organisms is produced. It is seen that a powerful germicidal action is exhibited by the regions between the wave-lengths 2960 to 2100 Å.U., with a region of maximum effectiveness between 2800 and 2540 Å.U., these rays are, however, completely absorbed by as little as 0·1 mm. of skin, so that ultra-violet radiation is only effective in killing organisms on the surface of a wound. The effect was determined for a variety of organisms, the range of susceptibility varies slightly, however, and would not afford a means of differentiating between the different kinds. It is further shown that the region of activity is coincident with that part of the spectrum for which the bacterial emulsion exhibits a strong selective absorption.

W. F. H.

A Contribution to the Study of Dosage in Radium Therapy. J. C. MOTTRAM, M.B., and S. RUSS, D.Sc. (Proc. Royal Society of Medicine, Vol. 10, pp. 121-135, 1917).—This paper gives a detailed record of experimental observations of a case of carcinoma under radium treatment. An ionization method was employed to determine the intensity of the radiation emitted by the several applicators used and in addition measurements of the absorption of the beta and gamma radiations by the skin and subcutaneous tissues were made. This was done in order to be able to compare the effect produced upon the skin when it is irradiated in such a manner that equal amounts of beta and gamma rays are absorbed by it. Details of the observations on the skin and subcutaneous nodules subjected to screened and unscreened beta and gamma radiations are given. As a result of the tests it is established that, firstly, if the skin is irradiated in such a manner that the neighbouring portions absorb equal amounts of beta and gamma ray energy, similar reactions are produced, but they are, in general, more pronounced in the case of the gamma rays. Secondly, if the skin is exposed to a large amount of beta or gamma radiation for a short time the reaction is more pronounced than if the same dose is given, using a smaller amount of radium for a correspondingly prolonged period. The effect on the malignant subcutaneous nodules was not, however, appreciably different in the two cases. W. F. H.

The following abstracts are selected from the current issues of "SCIENCE ABSTRACTS," and are published by permission of the Editor of that Journal.

1141. *Attempt to Separate the Isotopic Forms of Lead by Fractional Crystallization.* T. W. RICHARDS and N. F. HALL. (Am. Chem. Soc., J. 39. pp. 531-541, April, 1917. Nat. Acad. Sci., Proc. 3. pp. 339-345, May, 1917. Chem. News, 115. pp. 281-283, June 15, and pp. 294-296, June 22, 1917.)—Lead from Australian carnotite (believed to contain about 1 part of ordinary lead to 3 parts of RaG, with a mere trace of RaB) has been fractionally crystallized over 1000 times as nitrate, and the end-fractions purified. The atomic weights of the samples so obtained from the crystal and the mother-liquor ends of the series, respectively, agreed within the experimental error of 6 parts in 100,000. The β-ray activities agreed within the experimental error of 1%. These observations indicate that the nitrates of RaD and lead on the one hand, and RaB and lead on the other hand could hardly be separated, if at all, by less than 100,000 crystallizations. The outcome gives strong experimental support for the hypothesis that isotopes are really inseparable by any such process as crystallization. L. H. W.

1286. *Radio-activity of Meteorites.* T. T. QUIRKE and L. FINKELSTEIN. (Am. J. Sci. 44. pp. 237-242, Sept., 1917.)—Although the determinations of the radio-activity of various rocks are numerous, the radio-activity of meteorites is known for only two varieties and for only three specimens. The author now gives the result of his determinations of the radium content of twenty-two meteorites. From the data it appears that the average stony meteorite is considerably less radio-active than the average igneous rock (probably less than one-fourth as radio-active as an average granite) and that the metallic meteorites are almost free of radio-activity.
A. B. W.

1313. *An X-ray Tube for Research Purposes.* A. MULLER. (Archives des Sciences, 44. pp. 89-92, Aug., 1917.)—A detailed description is given of a specially designed X-ray tube. In ordinary X-ray tubes a considerable loss of intensity takes place due to several causes, namely: (*a*) bad focussing of the kathodic beam, (*b*) spreading (according to inverse-square law) after the X-ray beam leaves the antikathode and enters the air surrounding the bulb, (*c*) absorption on the glass walls of the bulb. A tube is now described in which these losses are reduced to a minimum. The antikathode is a thin metal window, at the end of the tube, placed at the focus of the kathodic beam. The X-rays are emitted from this window into the air almost without loss. Such a tube gives special facilities for studying the softer X-radiations generated at low voltages. As the surface area and volume of the tube are small, the vacuum can be obtained very quickly—in an actual case about 2 minutes for a "hard" tube. A. B. W.

1354. *The Life of Reinforcing Screens.* G. HARTUNG. (Archives d'El. Médicale, 25. p. 242, Sept., 1917.)—Specimens of screens are cut into equal parts. One part is placed in a special box at a distance of 17 cm. from the antikathode and acted upon by the radiation, the other is kept as control. After a total exposure of about 56,000 secs. the specimens are arranged upon a photographic plate and radiographed. In order to compare the effects so obtained with those obtained in practice, it is necessary to take into consideration that the usual distance of the screen from the antikathode is 50, not 17 cm. This means that it would require under normal conditions 484,429 secs. to produce a corresponding effect. If five radiographs with screen are taken per day and the exposure in each case is 2 secs., then it would take about 134 years to produce the same modification in the screen as that produced in these experiments in 56,000 secs.
A. E. G.

1372. *Monocular Method of Stereoscopy Applicable to Radiography.* J. B. TAULEIGNE and G. MAZO. (Comptes Rendus, 165. pp. 395-397, Sept. 17, 1917.)—It is found that with an ordinary tube, and consequently by a single emission without any special apparatus of observation, it is possible to obtain a true physical relief that is measurable and can be used in the exact localization of projectiles in the wounded. It is clear that a single image, absolutely fixed, cannot give in any case a sensation of true relief. But if the object under examination, or the focus of emission of the rays is made to undergo a small angle of displacement in a period ranging from one-quarter sec. to one sec., with an axis of displacement such that at least one of the planes

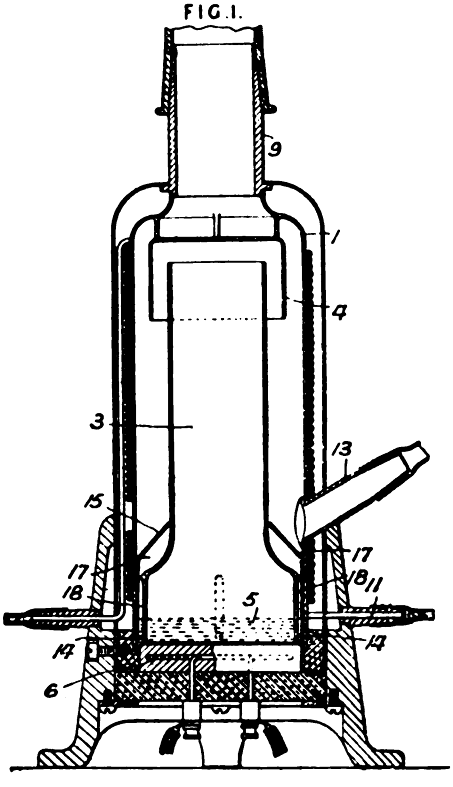
of the subject remains fixed upon the screen, then the other planes undergo a deviation so much the greater as they are removed from this fixed initial plane, and an image is created which has all the elements of stereoscopic vision. It is to be noted, however, that when such an image is viewed with both eyes no sensation of relief appears. It is also found that the apparent relief may be either direct or reversed. It is sufficient to shut and reopen the observing eye to obtain successively these two aspects of relief. Several observers viewing the same image at one time may thus obtain different views of its relief. It is expected that this procedure will be of great service in the radioscopic localization of projectiles, and still more in extractions under the screen.

A. E. G.

Abridgments of recent Patent Specifications bearing upon the subject of X-rays and Allied Phenomena.—Compiled for publication by H. T. P. GEE, *Patent Agent, Associate I.E.E., 25, Victoria Street, Westminster, London, S.W.1, and at 70, George Street, Croydon*

108,590. *Exhausting apparatus.* BRITISH THOMSON-HOUSTON CO., 83, Cannon Street, London.—(*General Electric Co.: Schenectady, New York, U.S.A.*) Oct. 18, 1916.—Relates to improvements upon the means for exhausting by means of a current of mercury vapour described in Specification 105,357. Within a cylindrical metal vessel 1 there is an upright conduit 3, surmounted by an open cap 4 and conducting vapour from mercury 5 heated by an electric coil 6. Passage of the vapour through the cap draws air downwards through a pipe 9 communicating with the vessel to be exhausted, condensation occurring upon the walls of the cylindrical vessel,

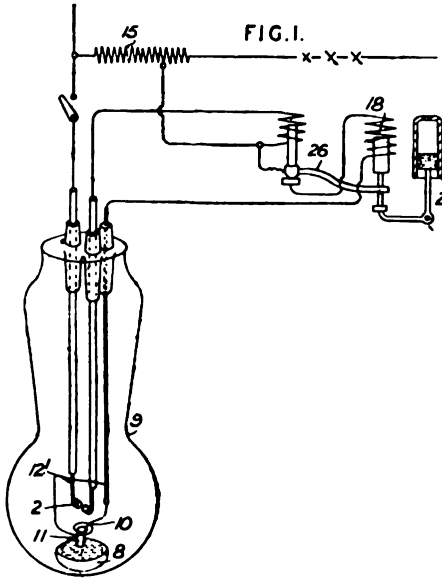
FIG. I.



which are cooled externally by means of a cooling coil 11 soldered to the wall, and the condensed vapour returning under the direction of a baffle 15 through apertures 17, 14 and grooves 18 to the main body of the liquid. A rough pump withdraws the air by a connection 13. In a modified form, the mercury-vapour uptake is bent over through 180 degrees into a somewhat similar but jacketed condenser, having a trapped communication with the vessel to be exhausted, this passage being subdivided by diaphragms so as to impede the flow of any mercury vapour towards the vessel.

109,188. *Electric arc-incandescent devices.* BRITISH THOMSON-HOUSTON CO., 83, Cannon Street, London.—(*General Electric Co.: Schenectady, New York, U.S.A.*) Dec. 27, 1916. *Drawings to specification.*—A sealed envelope enclosing electrodes, one at least of which operates at incandescence, contains iodine with or without inert gas such as argon. The iodine

may be introduced from a side-tube which is afterwards sealed off. When the apparatus is in use, the pressure of iodine vapour is at least half a millimetre of mercury ; a pressure of 50 mm. is advantageous. That of the inert gas may be several centimetres. Iodine reduces the drop in electric pressure, and the liability to conduct in the wrong direction. A rectifier may have an incandescent cathode of tungsten or other material and an anode of tungsten, molybdenum copper, or, when inert gas is present, graphite. Specification 5557/15 is referred to.



104,674. *Arc lamps ; vapour electric apparatus.* DEVERS, P. K., Lynn, Massachusetts, U.S.A. Jan. 8, 1917, No. 363. *Convention date, March* 6, 1916. *Abridged as open to inspection under section* 91 *of the Act.*—Tungsten or other refractory electrodes are enclosed in a sealed envelope containing a quantity of vaporizable material 8 and means for vaporizing and ionizing part of this material to facilitate the production of an arc. Mercury, an alloy, or, better, an amalgam of an alkali metal, such as sodium potassium, or rubidium, may be used. With mercury, a starting pressure of 200 volts is suitable, with working pressure in a 12 ampère circuit being, say, 15 volts. In the presence of an alkali metal, an initial pressure of 75 volts may suffice. An alkali-resisting glass envelope is required in the latter case. Inert gas, such as nitrogen, argon, neon or krypton, may also be included at a pressure of at least several mm. of mercury ; a pressure of 254 mm. is preferred. During burning of the lamp, the gas is displaced by the vapour into the space above a constriction 9. The heater shown is a tungsten filament 10 designed to operate at about 2000° C. and arranged just below the electrodes with a spur 11 dipping into the mercury, etc., 8. One end of the heater is connected to the supporting-wire of one of the electrodes 2, the other end being attached to a separate leading-in wire 12^1. A compensator 15, which may be one of a series, supplies current to the arc and heater circuits in parallel. Each circuit includes a solenoid operating a cut-out 26 for the heater ; the core of the solenoid 18 in the heater circuit has a lost-motion connection to the cut-out and is retarded by a dash-pot 24. In a modification, a transformer supplies both currents, and the cut-out disconnects both ends of the heater from the arc circuit. In another modification, independent transformers with primaries in parallel supply the arc and heating circuits. The solenoid in the heater circuit may in some cases be omitted.

109,358. *Producing high vacua.* BRITISH THOMSON-HOUSTON CO., 83, Cannon Street, London.—(*General Electric Co. ; Schenectady, New York, U.S.A.*) Dec. 14, 1916.—High vacua are produced in X-ray tubes, etc., by absorbing residual gases, oxygen, nitrogen, hydrogen, water vapour, oxides of carbon, etc., by metals of the rare earth group, particularly thorium and zirconium. Fig. 1 shows an X-ray tube with a cathode 2, preferably of tungsten, surrounded by a focussing ring 7. The anode 3 is carried by a tube 11 of iron or molybdenum. The tube is first evacuated and then filled with dry air or nitrogen. After introduction of the metal 15 in a finely divided state, the tube is again evacuated, and the metal is heated externally by a lamp to start a reaction with the gas to be absorbed. Fig. 2 shows a tube to be filled with a rare gas, such as argon, more particularly suitable for use as a rectifier but capable of other use, for instance as an oscillator. The metal 15 may be introduced by shaking it down into the bulb from the side tube 16, which is sealed off before the final evacuation. The invention is applicable for the purification of the rare gases, argon, neon, krypton, or xenon.

FIG. I.

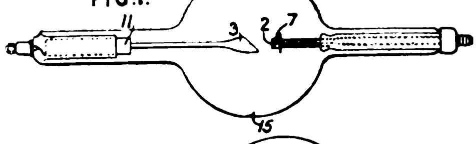
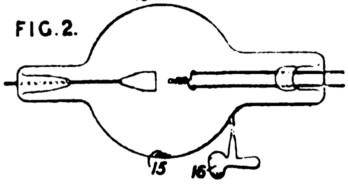


FIG. 2.



THE JOURNAL OF THE RÖNTGEN SOCIETY.

Vol. XIV. APRIL, 1918. No. 55.

EDITORIAL.

The editor regrets that there has been some unavoidable delay in the issue of the Journal, due chiefly to difficulties caused by present conditions, but although the war has disorganized and hindered many things it has given tremendous impetus in some directions, and the practical application of radiology is an instance of this latter.

The recent publication of the works of Dr. Robert Knox and others at home, and those just issued by the French press, that are announced in this number, speak plainly of the vitality of our science and of the energy and determination of those who practise it.

Since our last issue much work has been done in our Society and the membership still maintains a steady increase.

The Silvanus Thompson Memorial Lecture has been delivered and was a decided success; it will be published in full in our next number. Sir Ernest Rutherford gave a masterly exposition of the science of radiology; he paid a kindly tribute to the memory of the late Professor Silvanus P. Thompson and referred to the great interest he had always shown in the welfare of the Society.

A Medal has been struck for the occasion and was presented to the lecturer at the conclusion of his address. It is proposed to make a similar presentation at the conclusion of each annual Memorial Lecture. An illustration of the Medal is shown in the accompanying plate.

In view of the possibility that cases of distress may arise amongst our members as the result of the war or other causes, the Council has established a "Benevolent Fund" and has voted £20 for that purpose, further contributions by members are invited and can be sent to the Hon. Treasurer, who will from time to time furnish a statement of the fund. The first donation has already been made in the case of one of our very early members, who, having contracted X-ray dermatitis, is no longer able to continue work.

Our Library being for the time inaccessible, should any member wish to consult any of the publications recently announced, he can probably have the loan of the book on application to the Hon. Editor who, for the present, is compelled to be custodian of the volumes.

SESSION TWENTY, 1917-1918.

ORDINARY MEETING held at the Rooms of the Royal Society of Arts, John Street, Adelphi, on January 1st, 1918. Ballot, see page 68. Papers by **W. D. COOLIDGE and C. N. MOORE,** read by **CARL DARNELL, Esq.** The President, **G. W. C. KAYE, M.A., D.Sc.,** in the chair.

A NEW "RADIATOR" TYPE OF HOT-CATHODE X-RAY TUBE.

By *W. D. COOLIDGE.*

The type of tube described in this paper was developed specifically for use in portable X-ray outfits at the Front. Its characteristics are such, however, that it seems destined to ultimately supplant the earlier type of hot-cathode tube for all diagnostic work.

The Problem.

A study of the situation had shown that the electrical efficiency of existing portable X-ray generating outfits was low,* and that it could be very greatly increased if a suitable tube could be developed for operation directly from the secondary of a high-tension transformer, without the use of any auxiliary rectifying device. This condition of itself could have been fulfilled by the existing type of hot-cathode tube, using one with a large focal spot. As the portable apparatus was intended for diagnostic work, however, it was highly desirable that the focal spot in such a tube should be as small as possible for handling the required amount of energy.

The Status of the Prior Art.

The earlier form of hot-cathode tube with a solid tungsten target is capable of rectifying its own current, but only for such amounts of energy as do not heat the focal spot to a temperature approximating that of the cathode spiral. As soon, however, as any part of the focal spot is heated to a sufficiently high temperature, it emits electrons copiously, and therefore, when supplied from a source of alternating potential, permits so-called "inverse" current to pass. The "inverse" cathode-ray stream comes out from the focal spot in a direction perpendicular to the 45°-angle face of the target and proceeds, in the form of a narrow pencil, straight to the glass wall of the bulb close to and slightly behind the cathode. The glass at this spot fluoresces vigorously, becomes locally heated and usually cracks. As air enters the bulb, a spark discharge passes through the opening and it is then easy, for one who has not studied the phenomena, to conclude that the tube failed by puncturing under the electrostatic strain.

The local heating of the glass attendant upon overloading a tube which is running on alternating current, can be prevented by making the cathode focussing device of some refractory metal, such as molybdenum or tungsten, and so locating this in the tube that it intercepts the "inverse" cathode-ray stream.†

* The electrical efficiency of X-ray apparatus has usually been a comparatively unimportant fact, but as efficiency determines the weight and bulk of the entire X-ray generating outfit, it was obviously a very important matter in the present instance.

† Under these circumstances, the fact that the tube is being overloaded is shown by a sudden, vigorous local heating of the focussing device. In case the area heated in this way becomes sufficiently hot, it becomes a third source of cathode rays. These last cathode rays focus on the target at a point somewhat removed from the original and legitimate focal spot. This can be very *easily observed* and confirmed by the pin-hole-camera method.

While the above method has proved exceedingly useful as a safety device for such a tube which is to be used on alternating current, it does not appreciably increase its capacity, for it would obviously be undesirable to have the cathode focussing device giving off X-rays under such bombardment.

The essential condition to be fulfilled was that heat should be more rapidly withdrawn from the focal spot. This could have been accomplished by water-cooling, but this clearly involved undesirable complications for portable work. Experiment showed that the most effective simple method consisted in providing a target with a large heat capacity and high heat conductivity, and then seeing to it that this mass of metal was essentially cold at the time when the tube was to be given its full load. As an illustration of the importance of having the target cold at the start, it was found that with a tube having a $\frac{1}{8}$-in. focal spot and a solid tungsten target, it was possible upon giving this tube its maximum allowable energy input, when beginning with the target at room temperature, to run four times as long before "inverse" current appeared as when the experiment started with the target at dull red heat.

Now in the case of the ordinary Coolidge X-ray tube, the cooling of the target from dull red heat to room temperature is an exceedingly slow operation, as the heat can get out only by radiation, which, with small differences in temperature between the hot body and its surroundings, takes place at a very low rate, and by conduction through the small lead-in wire and through the glass.

Description of the Tube.

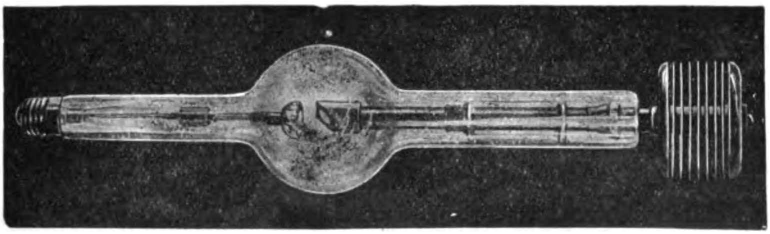


Fig. 1. The New Radiator Type Coolidge Tube.

The above considerations finally lead to the anode design shown in Fig. 1. The anode stem consists of a solid bar of copper, $\frac{5}{8}$ in. in diameter, which is brought right out through the glass of the anode arm to a copper radiator. The head of the anode consists of a mass of specially purified copper, which is first cast in a vacuum on to the tungsten button, and is then electrically welded to the stem. The tungsten button, which is destined to receive the cathode ray bombardment, is 0·100 in. thick and $\frac{3}{8}$ in. diameter.

The complete target, with radiator, has a heat capacity considerably greater than that of the present standard solid tungsten target. Roughly speaking, therefore, with a given high milliampèrage and voltage, the new tube would have to be operated several times as long as the one with the standard solid tungsten target to bring the target up to red heat. What is much more important, however, is the fact that, between radiographic exposures, the target in the new tube cools comparatively rapidly owing to the radiator.

In the standard hot-cathode tube with the solid tungsten target, the target gets quite hot and radiates the greater part of the energy it receives out through

the glass walls of the tube. As a result, the glass becomes quite hot. In the new Radiator-type of tube by far the largest part of the energy imparted to the target is conducted out to the radiator. It, therefore, becomes possible to make the glass bulb very small. For the portable work, a diameter of 3¾ in. has been standardized.

Theory of Operation.

In the radiator type of tube the passage of "inverse" current is avoided by construction which removes heat from the focal spot so rapidly that, in normal use, it never reaches the temperature at which an appreciable thermionic emission of electrons can take place. In testing out the first tubes of this type, we found that some other very powerful cause was acting to prevent electron emission from the focal spot. As a result of this, it developed that, in this tube, the temperature of the focal spot could be raised to that of the cathode spiral and even brought to the melting point, while the tube was operating on alternating current, without having the tube allow any appreciable "inverse" current to pass.

The most probable explanation of this phenomenon appears to be as follows:—The thermionic emission of electrons from a heated tungsten surface is very greatly reduced by minute traces of oxygen.* Now in the case of the solid tungsten target, the oxygen which is originally present in the metal is removed during the tube exhaust by maintaining the target for a considerable time at intense white heat, while the tube is connected to the pump. Under these conditions, oxide of tungsten dissociates, and the oxygen is removed from the tube by the pump. In the radiator type of tube, the conditions are very different. There is, at the beginning of the exhaust, a large amount of oxygen both in the tungsten button and in the copper of the target. During the exhaust, the temperature of the target must at all times be kept below the melting point of copper. As a result there is probably sufficient oxygen left in the target to account for the observed phenomena. The oxygen in the tungsten at the focal spot would be liberated by the heat produced by cathode ray bombardment. This oxygen would then be chemically removed from the surrounding space by the hot copper of the target. Other oxygen in the metal layers just behind the focal spot would then diffuse to the focal spot, and this cycle of operations would go on indefinitely, the trace of oxygen in the tungsten at the focal spot always greatly reducing the electron emission.

With a tube containing such a target, heat is conducted away from the focal spot so rapidly that it could satisfactorily be used to do the work for which it was intended without the help of the above mentioned phenomenon. The latter furnishes a factor, however, which strongly safeguards this type of tube when rectifying its own current.

The Exhaust.

The exhaust of a hot-cathode tube, containing the anode described above, to such a point that it could be sealed off from the pump, appeared at first to be an impossibility. A point was finally reached when the vacuum was good after sealing the tube off and allowing it to stand over night. Upon operating such a tube for a few seconds, however, the vacuum rapidly deteriorated until the tube showed a Geissler glow. After a second exhaust covering a period of several hours, the above experience was duplicated with this difference, that the tube operated successfully for a somewhat longer time. A third exhaust, again extending over a period of

* Langmuir.

several hours, finally resulted in a good tube. Since that time it has developed that the exhaust may be helped by a preliminary treatment of the electrodes, but it is still a very serious operation when compared even with that of the hot cathode tubes of the earlier type.

Limitations and Behaviour upon Overload of this First Model of the "Radiator" Type Tube.

The first model of the radiator type of tube has been designed to carry 10 milliampères at a 5-in. parallel spark for the time required for making the most difficult radiographs, and to carry a fluoroscopic load of 5 milliampères at a 5-in. parallel spark continuously for an indefinite period.

Under abuse, its behaviour is as follows:—

When operated continuously for 150 secs. at 10 milliampères at a 5-in. parallel spark and with a constant heating current in the filament spiral, the milliampèrage may gradually drop to as low as 6 milliampères. (The amount of this drop depends upon the exhaust, being greater the poorer this is.) Upon cooling the anode, the vacuum immediately returns to its original condition, as shown by the fact that, with the same filament current, the milliampèrage comes right back to 10. It is surprising to see how quick this recovery is—it takes place even in the short time that it takes to cool the anode by holding the radiator under a cold water faucet.

Measurement of voltage with Tube rectifying its own Current.

Upon operating a tube, which rectifies its own current, directly from the secondary of a transformer, the "inverse" voltage is always higher than the "useful." As a result, the measurement of tube voltage by a parallel spark gap used in the ordinary way would, in general, be very misleading, for the observed spark length corresponds to the "inverse" voltage and not to that which produces, and hence determines the nature of, the X-rays produced. A simple and very satisfactory method of dealing with this difficulty consists in connecting an alternating current voltmeter across the primary of the transformer and then, to standardize once for all this combination of transformer and voltmeter, to put a kenotron in series with the X-ray tube, so connected that it allows current to pass through the X-ray tube in the right direction. If now a spark gap is connected across the X-ray tube terminals, it measures the useful voltage (and this is essentially what it would be if the kenotron were not in the circuit, for the voltage drop in a suitable kenotron is not more than, say, one or two hundred volts and can hence be neglected), while if connected directly across the transformer terminals, it measures the "inverse" voltage. The difference between the two will depend upon the load, and hence it is necessary that the calibration should be made for every load which it is desired to use with the tube. Unless appreciable changes take place in the wave form of the current supply, a single calibration suffices, and this can be made by the manufacturer of the transformer. Unless otherwise specified, the voltage referred to in this specification is always the useful and not the "inverse" voltage.

Attachment of Radiator to Target Stem.

In the first radiator type tubes which were made, the radiator was soft-soldered to the copper stem of the target. It was later found that the tube would stand almost as hard abuse if the solder was omitted and the radiator was simply slipped on over the stem and held in place by a screw and metal washer. This has made it possible, for some applications, to adapt a simple close-fitting two-part lead-glass shield to the tube.

Lead-Glass Protective Shield.

As such a shield is, in some cases, a matter of a good deal of importance, it is perhaps well to discuss briefly a form which seems very satisfactory. First of all it is evident that for applications where the tube shield should, for a given amount of protection, be as light as possible, it should have the same form as the tube and should fit closely to the latter. Furthermore, it should let the heat energy of the cathode spiral radiate out through it, as otherwise both the shield and the tube would, with prolonged filament excitation, get very hot. The ideal light weight shield will then be a non-conductor of electricity, to permit of its being closely fitted to the tube, and will be transparent to ordinary light radiations. Glass containing sufficient lead would be a satisfactory material from which to make it. The ordinary X-ray protective glass with which the author is familiar does not have as high a lead content as seems desirable. The best samples which he has tested have to be used in layers 10 to 12 times as thick as metallic lead to give the same protection. Experiments made by Dr. Michel of this laboratory showed that glass could be made experimentally which contains so much lead, that, for the same protective effect the glass layer had to be only 1·4 times as thick as sheet lead. Such glass when melted attacks the glass-pot rather readily, and may therefore be difficult to manufacture, but the author has recently been able to obtain from the Corning Glass Works, glass containing enough lead so that a layer ¼ in. thick is equivalent in protective power to $\frac{1}{16}$ in. of metallic lead. The properties of this glass are such that it cannot be readily blown into thick-walled bulbs, but it can be pressed in

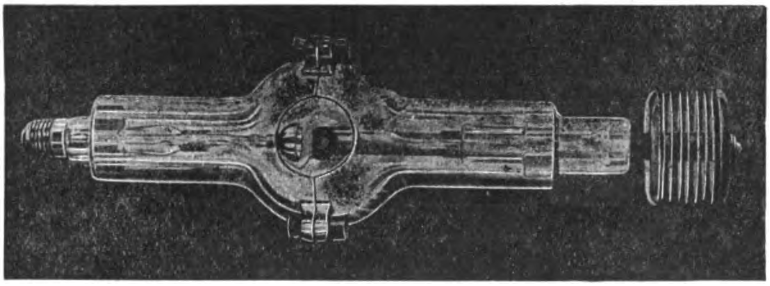


Fig. 2. Lead Glass Protection Shield in position on Radiator Type Tube.

moulds. Fig. 2 shows a picture of a tube surrounded by such a shield, which is made in two parts bolted together in the middle. A hole cut in one side permits egress to the desired bundle of X-rays.

Applications of the Tube.

Two portable X-ray generating units have already been built around the first model of this tube. These are the U.S. Army Portable Unit and the U.S. Army Bedside Unit. In both of these outfits, the tube is operated directly from a high voltage transformer with no auxiliary rectifying device.

The tube should also be useful for general fluoroscopic work and for all radiographic work which can be done with a focal spot as small as ⅛ in. in diameter. (This means an amount of energy not in excess of that corresponding to 10 m.a. at a 5 in. parallel spark between pointed electrodes).

For more rapid radiography, other models will be developed with larger focal spots, but probably with the same external tube dimensions.

Advantages of the "Radiator" Type Tube.

The advantages which the new type of tube possesses over the earlier type for diagnostic work are the following:—

(1) It can be used to rectify its own current under conditions of service which are much severer than would be permissible with the earlier type of hot-cathode tube having the same size of focal spot.

(2) The bulb can be smaller than is permissible with the earlier type handling the same amount of energy.

(3) On either alternating or rectified current it will carry the maximum allowable energy for a much longer time.

A PORTABLE RÖNTGEN RAY GENERATING UNIT.

By W. D. COOLIDGE and C. N. MOORE.

Introduction.

When it became apparent that this country was to become involved in the European War, various Red Cross Units were formed and some of these instituted enquiries concerning X-ray apparatus suitable for war needs. It was through such enquiries that the authors became interested in the problem of a portable X-ray generating outfit. It seemed at the time to be generally felt by Röntgenologists that nothing which was entirely satisfactory for this work had been evolved in this country.

The problem as it first presented itself seemed rather indefinite, as but little was generally known concerning the degree of portability required, the current and voltage needed to operate the tube, the amount of service which would be required of the apparatus, the question as to whether power could usually be had from existing electric circuits, etc.,*

Types of Apparatus Investigated.

The various types of apparatus which the authors seriously considered for the purpose were:—

(1) A gasoline-electric set furnishing low voltage direct current to a rotary convertor, with a step-up transformer and a mechanical rectifier attached to the shaft of the rotary.

(2) A gasoline-electric set furnishing alternating current to a step-up transformer and with a mechanical rectifier driven from a small synchronous motor.

(3) The same as 2, except for the substitution of a kenotron for the synchronous motor and mechanical rectifier.

(4) A gasoline-electric set furnishing alternating current to a step-up transformer, with a self-rectifying X-ray tube operating directly from the latter.

(5) A storage battery operating an induction coil through a mechanical interruptor or a mercury-turbine interrupter with suitable gas dielectric.

(6) A storage battery operating a motor generator and so producing alternating current to be fed to a step-up transformer and thence to a self-rectifying X-ray tube.

* Among others, the following paper bearing on the subject was read with great interest:— The X-ray Equipment and Work in the Army at the Present Time, by Captain William A. Duncan, Am. J. of Röntgenology, 268-275 (1914).

With 1, to avoid the use of long high-tension leads, it appeared necessary to locate gasoline-electric set close to the X-ray table and, hence, to make the operating room noisy. Furthermore, the efficiency of a small rotary is very low for the size in question, perhaps 25 per cent., and this would necessitate the use of a relatively large and heavy gasoline-electric set.

2 had, for this particular purpose, numerous objections. It practically necessitated placing the rectifier near the operating table where the noise was undesirable; its use involved the loss of a considerable amount of energy (the small one which we tried consumed 350 watts); its behaviour on the current supplied by a dynamo driven by a small single-cylinder four-cycle engine was not good; and finally, it looked like a serious complication provided it could be dispensed with.

3 was good, but was clearly not so simple or efficient as 4.

It developed that the electrical efficiency of both 5 and 6 was very low, probably less than 25 per cent. This meant that for the production of any reasonable X-ray intensity for any considerable length of time either of these systems would lead to a very heavy outfit.

System 4, consisting of a gasoline-electric set furnishing alternating current to a step-up transformer, and with a special X-ray tube operating directly from the latter, was finally chosen. The advantages of this system when compared with the others may be briefly summarized as follows:—

It is simpler.

It is more efficient electrically.

It is lighter in weight for a given output and hence more portable.

It does not involve the care of a storage battery.

It involves the use of no moving parts other than the gasoline-electric set.

The outfit is self-contained, requiring merely gasoline to run it, and can hence be operated anywhere at any time regardless of the presence or absence of electric supply circuits.

The one member having moving parts, namely, the gasoline-electric set, can be located at any desired distance from the X-ray room.

The Gasoline-Electric Set.

Various single and multiple cylinder engines of the two-cycle and four-cycle type were tried out and the conclusion was reached that the one of these which was best adapted to the purpose was the Delco-light engine made by the Domestic Engineering Company of Dayton, Ohio. This offered the further advantages that it was already direct-connected to a dynamo, with a capacity of about three-quarters of a kilowatt, and that it was thoroughly standardized and on a large scale production basis.

The Delco-light set was originally built for direct current at 40 volts, but by a change in armature and field windings and by the addition of a pair of slip rings and brushes, it was adapted to furnish alternating current at the desired voltage.

The reasons for choosing the Delco-light outfit in preference to others were the following:—

It has a single-cylinder engine with corresponding mechanical simplicity.

The engine is of the four-cycle type and hence easy to start and flexible in operation.

The engine is air-cooled, and this does away with the possibility of having water freeze in the jackets in cold weather.

The engine and dynamo are direct-connected and have but two main bearings. This effectively does away with coupling troubles and with lack of alignment.

It is self-lubricating.

It is of suitable capacity.

It has been developed for long continued service with a minimum amount of attention.

At great expense, it has been thoroughly standardized, and this means interchangeability of parts, and that all sets will have very nearly the same characteristics.

The workmanship is excellent.

It is available in any desired quantity on very short notice.

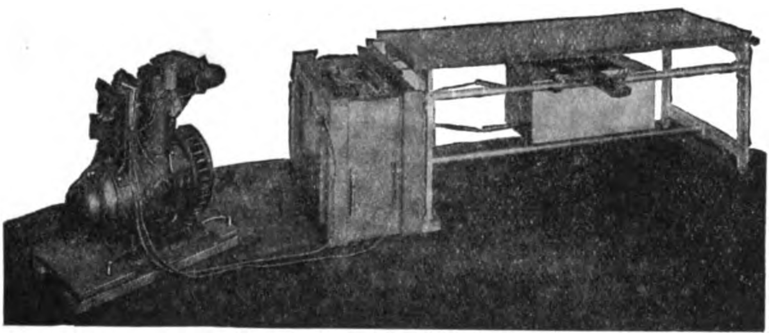


Fig. 1. Complete Portable Field X-ray Outfit.

General Description of the Outfit.

The complete outfit is shown in Fig. 1, in which the gasoline-electric set is seen at the left. The X-ray and filament-current transformers, the filament current control and a little " booster," whose function will be explained later, are in the box at the end of the table (see Fig. 2, which shows the inside of this box), and a voltmeter for showing line voltage, an adjustable rheostat for controlling line voltage, a milliammeter for indicating the tube current, and the operating switch are mounted on a shelf in the top of the box. (There is a cover for this box which is screwed on for shipment). The X-ray tube is permanently located in the movable tube-box under the table.*

General Description of the Outfit.

In the complete outfit, Fig. 1, the gasoline-electric set shown at the left delivers alternating current at about 45 cycles and 120 volts to a step-up transformer located in the box at the end of the table. This transformer is seen at the right in Fig. 2, which is a picture of the transformer and instrument box with the left-hand side (in Fig. 1) let down. In Fig. 2 a wire from the high-tension terminal at the right goes forward through the other side of the box to a reel which connects with the anode of the tube. The other high-tension terminal connects with the secondary of the filament-current transformer at the left of the box and so with one side of the double reel, and with the cathode end of the tube. The connections are shown in detail in Fig. 3.

* The table, tube-box and shutter were all developed by the co-operative work of others, including Major Shearer, Major Geo. Johnston, Major Cole, and the *Keley-Koett Company*.

The line voltage is held constant by the throttle-governor which may be seen in Fig. 1 located on the engine just above the carburettor.

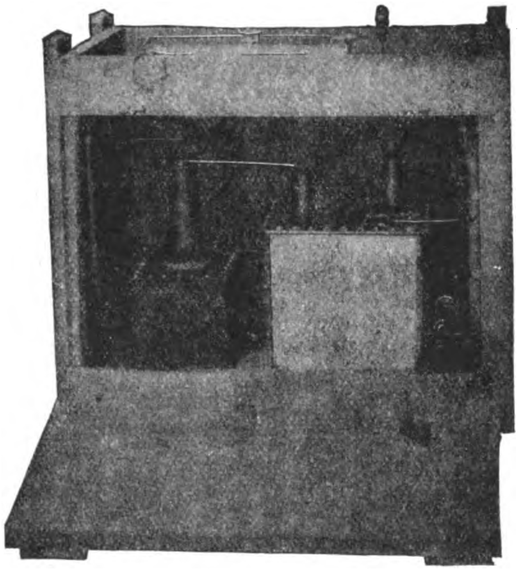


Fig. 2. Transformer and Instrument Box of Field X-ray Outfit.

The line voltage may be brought to any desired value by means of the adjustable rheostat on the top of the instrument box, next to the table.

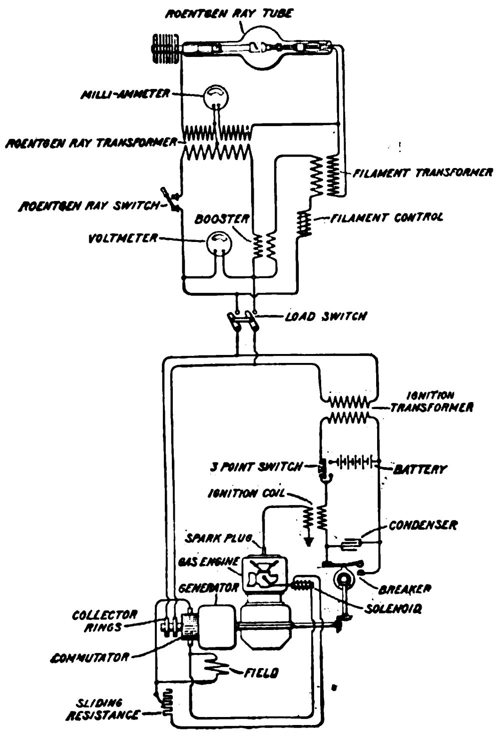


Fig. 3. Complete Wiring Diagram of Field X-ray Outfit.

A voltmeter for showing the line voltage, a milliammeter for indicating the tube current, and the X-ray operating switch are also seen in the top of the instrument box.

There is a filament-current control in the bottom of the transformer and instrument box (in the rear right lower corner in Fig. 2) and, in front of this (in this picture) a "booster" which prevents the filament temperature from dropping too much when the X-ray load is thrown on the system.

Fig. 4 shows the separate parts comprising the outfit.

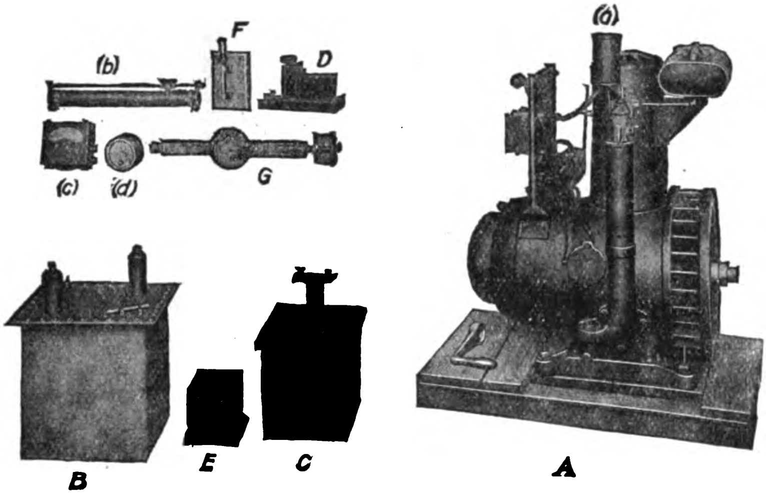


Fig. 4. Separate Units Comprising Portable Röntgen-Ray Field Outfit. A = Generator, petrol-driven.

By eliminating all auxiliary rectifying devices and leaving it to the tube to rectify its own current, it was found that the Delco-light outfit was capable of delivering to the tube 10 milliampères at the potential corresponding to a 5-in spark between pointed electrodes.

The Tube.

No tube suitable for diagnostic work and capable of rectifying its own current, for frequent long exposures, with as much energy as that corresponding to 10 milliampères, at a 5-in. parallel spark, was available. It therefore became necessary to undertake its development, and the result is seen on p. 39. This tube is fully discussed in a separate paper. Briefly, it is a hot-cathode tube with a $3\frac{3}{4}$-in. bulb. The cathode has been especially designed to give a focal spot $\frac{1}{8}$ in. in diameter and with a very uniform distribution of energy. The target consists of a very small wrought tungsten button set in a solid block of copper and this block is electrically welded to a solid copper stem $\frac{1}{2}$ in. in diameter which extends through the anode arm to an external radiator. The target, complete with stem and radiator, has a heat capacity which is several times that of the solid tungsten target in the earlier model of the "Coolidge" tube. For a given heavy load therefore, it must take several times as long to heat the target to redness as it does in the case of the solid tungsten target. Unlike the latter, the target in the new tube cools rapidly between radiographic exposures even at relatively low temperatures, and therefore permits

of starting each exposure with a relatively cool target. As a result, the focal spot, even though small, is kept from reaching a temperature high enough to allow "inverse" current to pass through the tube. Furthermore, and this seems an additional safeguard, this type of tube does not allow an appreciable amount of inverse current to pass, even though it is so badly overloaded that the focal spot becomes heated to the melting point. (A probable explanation of this striking fact is given in the paper on the tube which is above referred to).

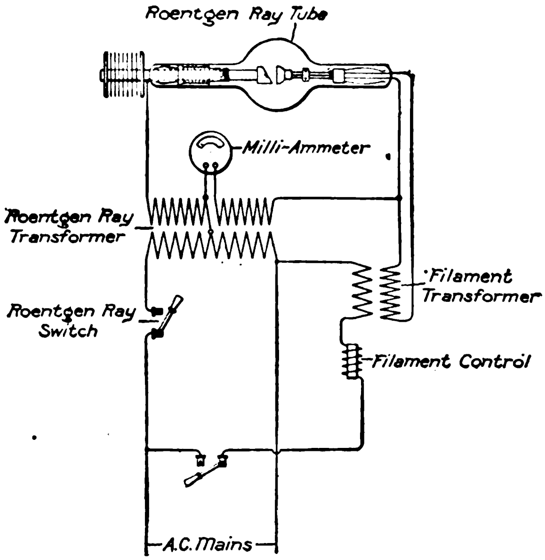


Fig. 5. Wiring Diagram for Field X-ray Outfit Operated Directly from Existing Alternating Current Mains (when Gasoline Electric Set is not needed).

The X-ray Transformer.

A small transformer, made by the Victor Electric Company of Chicago, for their dental radiographic outfit, was chosen for the following reasons:—

It is an oil-insulated closed-magnetic circuit transformer of the right capacity.

It is oil-tight.

Its design is such that, with the load in question, the "inverse" voltage is not prohibitively high.

It was available on short notice, as only two minor changes were required.

The Filament Current Transformer.

Here again it seemed imperative that an oil-insulated transformer should be used and that this should be electrically efficient, of light weight and oil tight.

The Victor filament-current transformer appeared to fulfil these conditions better than any other which was available at the time.

The Filament-Current Control.

The device manufactured by the Wappler Electric Company for control of filament current was chosen for this outfit because of its small size, fineness of regulation, and the fact that the setting, once made, was not easily disturbed. It consists essentially of a variable inductance, placed in series with the primary winding of the filament current transformer.

Regulation of Generator Voltage.

Regulation of generator voltage is accomplished by means of a special throttle

governor actuated by a solenoid which is connected in multiple with the field coils of the generator, and in series with a sliding resistance.

Control of Line Voltage.

By means of the adjustable sliding rheostat, located on the transformer box, and connected in series with the solenoid of the governor, speed of the engine, and consequently line voltage may be varied at will of the operator.

The Booster for Reducing the Drop in Line Voltage Caused by the Load.

It is important that filament current and consequently current in the primary windings of the filament transformer, should remain as nearly constant as possible. In order to compensate for drop in line voltage when the load is thrown on, a small "booster" transformer is used, its primary winding being in series with the low tension coils of the high-tension transformer and its secondary windings in series with the primary coils of the filament transformer. A complete diagram of the electrical connections is shown in Fig. 5.

Technique.

Experience extending over several years has convinced the writers that it is very convenient for experimental work, to have extreme flexibility in an X-ray generating outfit, so that the penetrating power of the rays may be varied at will between wide limits. It has also convinced them, however, that Roentgenologists would get better average results in diagnostic work if their outfits were made less flexible, so that the X-ray tube could be used more as the ordinary incandescent lamp is. When such a lamp is lighted on the ordinary constant potential circuit, it gives always the same kind and the same amount of light. It is entirely practicable to operate an X-ray tube in this same manner. It is merely necessary to see that the filament current is always the same and that the high voltage impressed upon the tube terminals is always the same. Under these circumstances the tube always gives out X-rays of the same penetrating power and of the same intensity. Slightly more artistic radiographs can be made by adapting the penetrating power of the rays to the thickness of the part to be radiographed, but experience shows that with a suitable compromise voltage (we have adopted that corresponding to a 5-in. spark between pointed electrodes—58,000 volts, as measured by a sphere gap) excellent radiographs can be made of all parts of the human body, and with a great simplification in apparatus and technique. The only variable becomes the time factor and this is adapted to the thickness of the part to be radiographed.

With 58,000 volts and 10 milliampères, and a distance of 18 in. from focal spot to plate, the writers have found that for Seed plates and the average adult subject the following table of exposures gives good results.

Exposures 18 *in. distance.*

Hand	1 second.
Elbows	2 ,,
Shoulder	8 ,,
Ankle	2 ,,
Knee	4 ,,
Hip	20 ,,
Chest	10 ,,
Head—lateral	25 ,,
Head—frontal sinus	50 ,,

Too much weight should not be attached to the above table, as it is based on

a relatively small amount of work. It is merely given to show in a general way how the time of exposures varies for different parts of the body when the intensity and generating power of the rays are held constant.

The above compromise voltage used for radiography appears equally well suited to fluoroscopy, and, at this voltage, a current of 5 ma. appears to give sufficient illumination.

The authors recommend the following methods of using the outfit.

After starting the engine, the resistance in series with the solenoid of the throttle governor is all cut out. This causes the engine to idle at its lowest speed.

For radiographic work, the resistance of the solenoid governor circuit is raised until the line voltage (indicated by voltmeter located on the transformer box) is about 160. The filament current is then adjusted once for all,* by means of the control until, upon closing the X-ray switch, the milliampèremeter registers 10. As the X-ray switch is closed, the line voltage is seen to drop. The resistance of the solenoid governor circuit should be changed until the line voltage with the 10 ma. load is 122. Observe what the line voltage is when the load is taken off, and in future adjust for this before closing the X-ray switch. The voltmeter reading, which must be right, is that when the load is on.

For fluoroscopic work, do not touch the filament current control. Leave it just as it was for radiographic work and use that setting of the adjustable rheostat which will give upon closing the X-ray switch a tube current of 5 ma.

Advantages of the Outfit.

(1) Control of line voltage, making it possible to duplicate electrical conditions and X-ray results very accurately.

(2) No moving parts other than the gasoline-electric set.

(3) The gasoline-electric set can be placed at any desired distance from the high tension part of the outfit, so as to avoid noise in the operating room.

(4) No storage battery to get out of order.

(5) Engine can be made to idle at very low speed, conducive to long life. This advantage comes with the use of the voltage instead of a speed governor.

(6) The tube has been designed to carry all of the energy that the generator can deliver.

For this reason no harm can be done to the tube by raising the filament current too high. Under such conditions the milliampèrage will go up, but the voltage will decrease so that the energy delivered to the tube will not go up appreciably.

(7) An accidental short-circuit of the generator will do no harm, it will simply lower the line voltage to such an extent that the field excitation will go down, the ignition will fail and the engine will stop.

(8) Simplicity of apparatus.

(9) High efficiency with consequent light weight and portability.

---

* It should need to be changed only when tubes are changed.

The following data obtained from one of these outfits may be of interest.

Weights.

Engine and generator, with wooden base	377
Tube box and shutter	110
Table	93
Table top	42
Transformer and instruments box with contents ...	244
	866 lbs.

Gasoline Consumption.

Speed R.P.M.	Load.	Hrs. per gallon of gasoline.
900	Filament	$5\frac{1}{2}$
1440	(160) filament	4
1382	(122) 10 m.a.	$3\frac{1}{2}$*
1320	(114) 5 m.a.	$3\frac{1}{4}$

Load.	Speed, R.P.M.
90v. Fil.	882
160v. ,, ...	1364
122v. —10 m.a. fil.	1378
130v. —Fil.	1184
114v. —5 m.a. fil.	1252

Energy.

Total A.C. energy taken from generator measured at slip rings =820 watts.
D.C. energy for field excitation =289·5 watts.
,, ,, voltage regulator =11·2 watts.

Distribution of Energy.

Line loss	10 watts.
Booster loss	12·2 ,,
Filament regulator loss	14·5 ,,
Filament transformer loss	4·6 ,,
Filament	43·0 ,,
X-ray transformer	693·5 ,,
	777·8 watts.

Point Spark Gap Calibration.

5 in. gap (point gap) 57,500v. (sphere gap).

$\frac{575}{690} \times 100 = 83$ per cent., the per cent. amount of energy delivered to X-ray transformer which goes into the tube.

$\frac{575}{829} \times 100 = 70$ per cent., the per cent. of the energy taken from the slip rings which is delivered to the X-ray tube.

Improvements which could be made by Special Design.

By special design, improvements could easily have been made. This did not seem wise at the time owing to the need of immediate availability.

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* X-ray load on for 15 sec. and off for 45 sec. each minute.

Desirable Change.

The outfit described was developed primarily for army use, and the exigencies of the occasion made it necessary to make use, in so far as possible, of parts which were already in production and hence readily available. It can be further simplified by special design.

The greatest improvement would come from a reduction in the "inverse" voltage. By proper electrical design of the dynamo and the high voltage transformer, this could readily be reduced to where it was but slightly in excess of the "useful" voltage. If, for example, the difference amounted to only ½ in., then the insulation required would be that for a 5½-in. spark gap instead of an 8-in. spark gap. The length of the X-ray tube and tube box could then be materially reduced. This would give more tube travel under the table.

It would also make it practicable and easy to work with a high-tension system grounded on one side. The cathode of the tube would then be connected to the lead covering of the tube box and through this and the supporting mechanisms to the grounded metal frame of the table. There would then be only one high-tension terminal to the transformer and only one high-tension wire going to the tube (to the anode). The grounding of the cathode end of the tube would make it possible to dispense with the bulky filament current transformer insulated for high potential and to replace it with a very small ordinary low voltage transformer. It would also increase the allowable tube travel, as the grounded end of the tube could then safely be moved to the extreme end of the table.

The set described above is intended to be used as a unit; but it would be a simple matter to so modify it that it could be operated from existing electric circuits without running the gasoline electric set. For this purpose the X-ray and filament current transformers would have special primary windings with several taps, to take care of the different voltages which might be encountered. There is already sufficient iron in them to take care of the range of frequencies from 25 to 133 cycles per second. For operation from direct current mains, a rotary convertor would be added, with connections for 110 or 220 volts. When operating in this way from existing electric mains, with either alternating or direct current the booster would not be needed and its primary would therefore be short-circuited.

The reason for adopting the energy input corresponding to 10 m.a. at a 5-in. spark gap was that it was the maximum amount available in the tube when operating from the Delco light generator.

This energy could, of course, have been taken at any desired potential, as this was merely a matter of transformer design. The reasons for choosing the potential corresponding to a 5-in. spark were as follows:—Given a certain amount of energy to work with, the X-ray intensity as measured by the illumination of the fluorescent screen or the action on this photographic plate, goes up rapidly with the voltage. This is obvious from the well-known fact that X-ray intensity measured as above, increases with the first power of the milliampèrage and with the square of the voltage, while the energy delivered to the tube is proportional to the product of the first power of the current and the voltage. This then was an argument in favour of high voltage. Contrast in both radiography and fluoroscopy, however, decreases with increasing voltage, which is an argument against the use of too high a voltage. The voltage corresponding to a 5-in. spark between points appeared to be a good compromise.

The

SILVANUS THOMPSON MEMORIAL MEDAL

STRUCK IN 1918 TO COMMEMORATE THE FOUNDING OF THE RÖNTGEN SOCIETY IN 1897,
WHEN PROFESSOR SILVANUS P. THOMPSON, F.R.S.,
BECAME FIRST PRESIDENT.

• • •

FIRST AWARDED TO PROF. SIR ERNEST RUTHERFORD, F.R.S.,
ON THE OCCASION OF THE DELIVERY OF THE
THOMPSON MEMORIAL LECTURE ON APRIL 9TH, 1918.

PLATE III.

DISCUSSION.

Dr. G. B. BATTEN asked for particulars of the kenotron and the purpose for which it was used in the apparatus. How was the current for heating the cathode obtained, and would it be possible to obtain the small size Coolidge tube suitable for a 9-inch spark gap and a current of 1-2 milliampères to use for therapeutic purposes?

Dr. HERNAMAN-JOHNSON, while congratulating the designers of the apparatus upon their success in producing such a powerful outfit in so small a compass, considered that the suggestion of varying the time factor only would limit the excellence of the result; the great advantage of the Coolidge tube was that you could vary the penetration of the rays to suit your subject by regulating the temperature of the cathode, a point of very great value.

Dr. G. H. RODMAN asked how long it would be possible to "run" the tube, without risk of breaking it down, and while complimenting the author upon the production of the hot cathode tube, drew attention to the fact that the Society had a very representative collection of "Historical X-ray Tubes," from the original "Focus" tube of Crookes, dated 1879, to the comparatively recent water-cooled tubes, and that the Society would welcome any examples of the tube that Dr. Coolidge had introduced, to add to the collection and bring it up to date.

Mr. W. E. SCHALL: There is one point I would ask, and that is whether the X-radiation which is obtained from the tube is homogeneous. The question of the relative value radiographically of the alternating wave obtained from the interrupterless high-tension transformer and the high-peaked wave from an induction coil is an old hobby of mine, and I am inclined to think that we do not obtain a homogeneous radiation when using the alternating wave. I was wondering whether the use of a hot cathode tube gets rid of the trouble which one experiences with the ordinary tube when using this sine wave, or rather just one phase of it, namely, that the current is being put through the tube at a large range of voltages, and that therefore a mixture of X-rays of various penetrating powers is generated. I notice that the time mentioned for the shoulder exposure was 8 seconds with 5 m.a., that is 40 m.a., seconds. I rather thought that with a coil one could get the shoulder in 25 m.a., seconds. That would rather suggest that the value of the milliamperage with the alternating wave is not quite so high as with the high-peaked spark coil wave, which, of course, is a well-known fact so far as the ordinary X-ray tube is concerned.

Mr. A. E. DEAN suggested that the Hogan transformer, which was self-rectifying would work an ordinary Coolidge tube quite well and was quite free from moving parts.

Mr. E. E. BURNSIDE: I should like to thank Mr. Darnell for his most interesting papers and his demonstration of this new Coolidge tube and transformer. Without knowing of this apparatus my firm have also produced a portable transformer apparatus which I am proposing to describe at our next meeting.

It is essentially a small "Snook," and being fitted with a rectifier is not quite so portable as this apparatus. The absence of a rectifier in Mr. Darnell's machine,

made possible by the new Coolidge tube, is a great advantage, and the combination of this tube and transformer should therefore be very useful.

I was very interested in the lecturer's description of the emission of oxygen from the copper of the target and its absorption by the tungsten. It is very difficult to get a conception of exactly what is going on, and I shall hope to hear more about this subject on a future occasion.

Capt. ROBERT KNOX: There is so much to say with regard to these papers that it is difficult to know where to begin. The American Government, in the first place, is to be congratulated on the manner in which it has tackled the problem of X-ray work in the army. The Government has done the right thing in trying to standardize apparatus as much as possible, and certainly over there the people who have done the work for the Government have succeeded in standardizing the X-ray tube to a great extent. We in this country have not yet standardized anything, so far as I know. We have all sorts of apparatus working in different places, different types of tubes, and so forth, but soon I hope to see a serious attempt made at standardization. What we have seen to-night seems to be a very important step in that direction. The small type of machine which we see here is infinitely better than any portable apparatus we have in this country, and has none of the attendant disadvantages of a coil outfit on a trolley with a mercury interrupter, which is dependent largely on an inefficient gas supply for its working. With a small outfit like the one shown, which one can connect to an ordinary light attachment, one may get practically as much current as from anything we have tried up to now in the way of portable outfits. At King's College Hospital we have a 15-16 in. coil running with a mercury break, the current being supplied from the main, and with that we can get up to 10 ma. comfortably. With an apparatus of that kind quite satisfactory work can be done in the wards, and that is a point which has been too much neglected. I hold that there are cases, such as fracture of the femur, where the extension apparatus is used, in which it is really impossible to move the patient from the bed, and an apparatus of this kind which can be wheeled up to the bedside is greatly to be desired. For that reason I have always advocated the use of a portable apparatus for that kind of work. What Mr. Darnell has shown us seems to be a very admirable field outfit, but I should like to know exactly what is meant by a field outfit in connection with war work. If it is designed to work actually in the field, right up at the front, the need for an apparatus of this kind is not very obvious. The casualty clearing stations should, of course, be fitted up with proper apparatus, and for that purpose something is wanted a little more powerful than the apparatus Mr. Darnell has described. It should be possible at the casualty clearing stations to do really rapid work, in seconds, or in fractions of seconds, and I question whether the machine we have seen to-night is strong enough for that. But in the field itself, actually behind the fighting line, I think that very little of that work can be done. I should like to know, therefore, what is meant by a field outfit. Then Mr. Darnell referred to a table of standard exposures, and I think he told us that the current is kept constant and that the varying factor is the time. That is very good for quite ordinary work, but what I would like to see developed would be the time factor constant and that at the shortest possible time—that is to say, the single impulse—while any variation could be made by varying the quantity of current passed through the tube. That is a development we must soon have. We want the shortest possible exposure in order to get the

sharpest possible negatives, and this can only be done by keeping the exposure down and varying the quantity of current, rather than the other way about. This particular development of the Coolidge tube is a very great advance. It will be extremely useful for screening work and for ordinary radiographic work, and with further developments, which I do not doubt will be forthcoming, it will possibly do all the work we want, even down to the single impulse exposure. I should like to congratulate Mr. Darnell on the very lucid way in which he has described it to us.

Mr. DARNELL, in reply, said: With regard to the kenotron, this is a commercial instrument largely used in the United States for the rectification of unidirectional current for smoke precipitation. It is a pure electron discharge tube, so adjusted that the filament can be heated up sufficiently to carry all the current required, and do that without any appreciable fall in voltage across the tube. The tube is not designed for therapeutic work. The varying of the penetration, however, is quite an easy matter. The limit of 5-in. spark gap is a limitation imposed by the apparatus. The tube is good for a 10-in. gap, the same as the standard tube. I wish to say incidentally that although credit has been given to the General Electric Company, they had nothing to do with the turning out of the actual generating machine. I wish further to say that the apparatus is only put forward tentatively and not by any means as a finished product. We expect that, having the tube self-rectifying, a much better apparatus will be developed, both in America and England. Mr. Deane has asked about the Hogan transformer; I am not familiar with this at all. Dr. Knox has put some questions about the field outfit. That is rather beyond the sphere of myself and my colleagues. It is something which has been developed by the United States army. They asked for a certain output, and a machine was developed which would give them that certain output along with a certain amount of portability. There again the limitations are in the engine and transformer used, not in the tube. I do not know what the life of the tube is; nor do I know that anyone does. We have, of course, spoiled tubes in the laboratory. I might tell you more about the life of the tube if I knew what is the limiting factor in any tube. At a 5-in. spark gap and with 5 ma. the tube could be run until one got tired of it. The crackling of the glass, I freely admit, is an unpleasant sound, bnt it seems to be due to some general expansion, and does not give any trouble. We have had some trouble in getting a proper supply of glass, and have developed glass-making in America. It is treated by methods which have been described in the publications of the General Electric Company—a treatment given to the bulb in the laborotary in order to prevent the liberation of gas from the inner surface. The transformer could be built for a higher voltage. If a transformer were built for the same energy output with a higher voltage it would not be much heavier than the one on demonstration; it would be just a little larger. The difference would be purely one of installation. As to the homogeneous wave, I am quite sure we do not get a homogeneous bundle of X-rays. As to the comparative value of the transformer and the coil, again I cannot tell. There are varying opinions on that subject. I have heard it discussed a great many times. The only thing I can say is that in America where both coils and transformers are available, we do not use coils. I do not know anyone who is using a coil for the generation of X-rays at present—certainly none of the advanced men are doing so. With a coil there is limitation in the energy input. Someone has spoken of change in the hardness of the ray. There is no change in hardness in the Coolidge tube at any time. It

is always just as hard and just as soft. The apparent change is usually a limitation imposed by the possible energy input of a generating apparatus, but with a constant source of potential—say, 75,000 volts—no matter what filament temperature was imposed one will always have 75,000 volts and always an emission of X-rays characteristic of 75,000 volts across the terminals. The thermionic stream is a fixed matter ; it has nothing to do with the resistance of the tube. I cannot say anything about the possible burning of the patient ; I am not a physician. There are many ways, of course, in which soft rays, if dangerous, can be filtered out. I wish to say in conclusion that the machine itself—the unit—is not to be put to the credit of the General Electric Company, who merely suggested the assembling of the parts. I think that one or two speakers have been rather unjust to their countrymen in suggesting that the British are slow. They have been fighting for the past two or three years and they cannot fight and run at the same time.

The PRESIDENT, referred to the part played by the copper of the anticathode in absorbing the gas liberated at the focus spot which was very interesting, the use of copper as a backing for the tungsten target, in addition to its high conductivity for heat, had the advantage that any stray cathode rays falling upon it would not produce X-rays in appreciable quantity on account of its low atomic weight.

He thanked Mr. Darnell in the name of the Society for the very interesting demonstration, and the authors of the papers for their contributions.

SESSION TWENTY, 1917-1918.

ORDINARY MEETING held at the Rooms of the Royal Society of Arts, John Street, Adelphi, on February 5th, 1918. Ballot, see page 68. Papers by **G. B. BATTEN, M.D.,** and **E. E. BURNSIDE.** The President, **G. W. C. KAYE, M.A., D.Sc.,** in the chair.

INTRODUCTION TO A DEMONSTRATION OF A SIMPLE MEANS OF OBTAINING "STATIC MODALITIES" FROM A COIL.

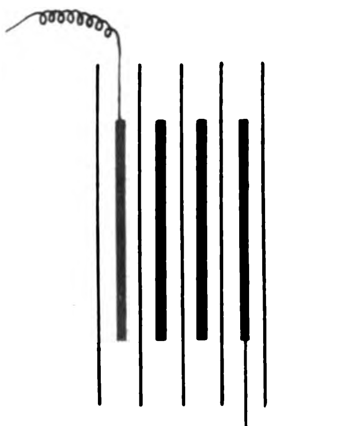
By G. B. BATTEN, M.D.

Static electricity has been known for twenty-six centuries, for, as its name implies, it was then found that a piece of amber (ἤλεκτρον) when rubbed attracted small particles, and this was by means of a static charge.

Although static electricity has no doubt been used with therapeutic intent for many centuries, I think it may be safely said that it had very little therapeutic effect except by suggestion until Dr. W. J. Morton, of New York, early in 1881 introduced the static induced current. From that time, however, the static modalities found a very useful place in electro-therapeutics. In 1899 the same worker gave us what is now known as the static wave current, or more usually the Morton wave current, which I believe holds an almost unique position in the treatment and cure of several painful affections, such as sciatica and other forms of neuritis. Static electricity has been very largely used in America, but to a much less degree in Great Britain, probably because in this damper climate it is more difficult to keep large

static machines in a constant state of efficiency. Nevertheless it has been very successfully used by some eminent electro-therapeutists (some of whom I have the pleasure of seeing here to-night), and I may say that I have often envied them the possession of really efficient static machines, with which they were able to relieve patients of mine whom I sent to them, of their painful complaints. About six years ago, when I sent a relative of mine, who was also a relative of Professor, now Sir Herbert Jackson, to an electro-therapeutist for static treatment, Professor Jackson said to me "Why don't you treat her yourself? Static electricity is essentially the same as any other electric current," and when I asked him how I was to do it, he replied "Well, I don't quite know, but all you have to do is to cut the ampèrage out of it without the voltage." This suggestion stuck in my mind, but the few crude experiments that I tried at that time, by the resistance of tumblers of water in cascade, only led to failure. In August of last year (1917), after reading the paper by Doctors J. A. Shorten and T. W. Barnard, of Bombay, on the suppression of inverse current from the secondary of coils by earthing the negative, I was led to think again of the problem of obtaining static currents from a coil. Soon after this, when treating a patient by X-rays from a very high tube, I noticed a distinct "breeze" coming from the end of a stick which I had placed under one of the high-tension wires to keep it further away from her hair.

"That surely is a static breeze," I thought, and so began experimenting again and very soon found the simple means of cutting down the ampèrage, or rather the milliampèrage of the current from a coil without much impairing the voltage, which I hope shortly to demonstrate to you to-night.



SERIES CONDENSER

Fig. 1.

After having worked out the method, I tried it with a very small and old insulating stool which I had borrowed from a friend, and having found it successful in producing on myself a current like the Morton wave current, I started to look up price lists so as to get a proper insulating stool. I then discovered that in 1908 the Cavendish Electrical Company had made and advertised a simple device for obtaining

static current from a coil. I rang them up and found that they had given it up, as it had proved unsatisfactory, and I understood them to say that the method they had adopted for cutting down the current was a slightly damp stick or other water resistance, and it was probably the variation in dampness or in conducting power that made this device unsatisfactory. Well, my device, shown in Fig. 1, is simply a series condenser or condensers, a condenser in fact where there are several pieces of tinfoil or conducting material separated by glass plates as the dialectrics, and in which none of the pieces of tinfoil are connected with each other, as is shown in this diagram. The sizes I happened to select as efficient were four pieces of tinfoil, each 8 by 5 inches, separated by plates of cleaned photographic glass 12 by 10 inches, and all insulated by hard wax. The first piece of foil is attached to the wire from the coil and the last piece to the electrode to the patient.

Fig. 2 shows the whole device. It consists of

1. An induction coil with a long fine secondary winding; any of the old coils which have been discarded of recent years, because they did not give enough milliampèrage for modern X-ray tubes, will do. A coil with a thicker secondary winding will not do nearly so well.

2. An adjustable alternate spark gap with ball terminals, and preferably enclosed, to drown the noise of sparking.

3. An adjustable series point-to-plate spark gap to cut down the inverse current enclosed with an oscilloscope attached.

4. The special condenser or condensers already described.

5. A good insulating stool.

The method of using is to cut down the current in the primary to 50 or even 35 volts and to make the time of contact in the turbine or other mercury interrupter very short.

To make a good earth contact from one of the secondary terminals, and to take the current from the other terminal through the series spark gap, the oscilloscope

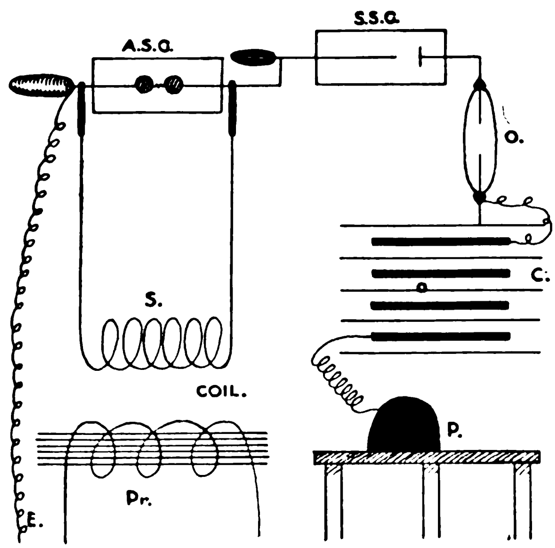


Fig. 2.

the special series condenser or condensers, and then to the patient on the insulating stool. Of course, all this side, including the condensers, must be well insulated from earth.

Now a static current has been defined as a constant unidirectional current of high potential and very little ampèrage. It is therefore quite impossible to obtain a true constant static current from a coil or a step up high-tension transformer, from which the current is in the first case interrupted and in the second alternating. I therefore do not claim to be able to obtain true static current from a coil, but I do claim to obtain all or nearly all, the effects of the " static modalities," or methods used for treatment by a current from a static machine, by using the unidirectional interrupted current of high potential and very little ampèrage supplied by means of this device from an induction coil suitably wound. There are six chief modalities used in treatment by the static current, diagrams of which I have copied by the author's kind permission from Dr. Howard Humphris's most excellent book on Electro-therapeutics.

i. The static bath.
ii. The static brush discharge.
iii. Static sparks.
iv. The high potential glass vacuum tube current.
v. The static induced current.
vi. The static wave current.

In the first three the positive is earthed, the alternate spark gap kept open and the negative led to the insulating stool. In the fourth, with glass vacuum tubes, the positive is still earthed, but the alternate spark gap is shortened so as to allow sparking between the balls and the vacuum electrode is applied to the patient on the stool. In the fifth, the static induced current, neither terminal is earthed, but they are led to one coating of two Leyden jars and the other coatings are led to the patient. This is a rather more severe treatment, and using it with my device the current, both in the main and in the secondary, must be well cut down, in the latter by at least two series condensers on each side.

In the sixth and most useful the *static wave current* the negative is earthed, the alternate gap adjusted to spark and the positive led to the patient on the insulating stool. The strength of the current and its effect on the patient may be modified in several ways when using my device with a coil.

1. By varying the current to the primary of the coil.

2. By varying the length of sparks between the balls of the alternate spark gap, the longer the sparks the stronger the effect on the patient.

3. By varying the length of the series spark gap, the longer the spark in this case the less the effect.

4. By varying the size and number of the special series condensers.

5. By varying the size of the electrode in contact with the patient. The larger the electrode the greater the current, the less the patient feels and the less the muscular contractions, other things being equal.

With an ordinary static machine the rate of sparking is varied in one or two ways; with a coil, of course, it is chiefly, but not entirely, influenced by the rate of interruptions in the interrupter, but it can also be varied by the relative adjustment of the two spark gaps and by the size of the discharging balls and by the size of the series condensers.

I have noticed and, of course, it is well known that small muscles, such as those of the hand and forearm, will respond to much more rapid stimulations than will the larger muscles, such as those of the thigh or the trunk; it is therefore necessary to run the interrupter and set everything else so as to make the rate of stimulations quite slow when treating the larger muscles. This with a direct current is most easily done by employing a dipper interrupter and running it slowly. When working with the alternating current, however, the rate of interruptions is governed by the periodicity of the alternating current in the main, and this is much too fast for all but the small muscles.

A method I have employed successfully at my home with the alternating current is to interrupt the secondary current between the series condenser and the patient by means of a "Kater" pendulum, suggested to me by my friend Mr. George Sutton, and swinging this so as to give from one to two interruptions per second, and with this I found the large muscles contract nicely. The strength of these contractions can also be increased by partially earthing another part of the patient by a well-known device preferably under the patient's own control.

It is a little early to speak very decidedly as to results of treatment, and I will not bore you with a recital of many cases, but will select two of my early ones as examples. 1. A youngish married lady who, besides managing her household, had worked very hard in a Government office where her work necessitated turning over papers by the hundred thousand. She contracted occupation neuritis, in the left arm and shoulder, with great pain in shoulder and upper arm and some pain and decided numbness in radial side of forearm and hand. The pain caused by turning over even the pages of a book was so intense that despite various treatments by radiant heat and drugs, etc., etc., she had to give up her work, but even then got no relief. In October I gave her four combined treatments, *i.e.*, with heat from a 3,000 candle-power "half wolt" lamp which I had tried alone for her before, and now with the Morton wave current applied to her shoulder by a metallic gauze electrode and by a large metal electrode held in the hands. After the fourth treatment, which was rather a long and severe one, she had worse pain the next day, but the day after that it quite disappeared and has not since returned in her shoulder or upper arm, and she could turn over papers with comfort. She did not got rid of the numbness in her forearm and recently she has had a slight return of pain in her forearm and elbow. I therefore applied the Morton wave current again to hand and elbow, with a large metal handle, by an electrode on the forearm and by a vacuum electrode and she has been completely relieved and now the muscles in her left forearm, which had become wasted, are growing and are nearly as large as in her right or good forearm. The second case was an elderly lady, who after pneumonia two years ago, had to nurse her husband through a long illness; her right arm had become weak and numb after her pneumonia with loss of power of grasping and some pain after using. I gave her six treatments in October with the Morton wave current, applied through her hand, and by the high potential vacuum tube to her arm, and this entirely relieved all her symptoms.

I do not claim that this device of obtaining static modalities from a coil is as good as the true static current from a really large and efficient static machine, but I believe it will prove to be more effective than the current from the under-powered static machines often used. Anyhow, I feel sure it will bring these static modalities within the reach of many medical men and therefore of patients who would otherwise

have to do without this valuable aid. I foresee the following advantages of this device over ordinary static machines.

1. Economy.
2. Ease of control.
3. Portability.

There is no reason why quite a small light, specially wound coil should not be made sufficiently powerful and yet able to work from any lamp socket in a private house or hospital ward.

4. Reliability.

This is most important, for a coil will work well under any weather conditions. You will please remember that the apparatus I have hitherto used was made up of material I had at home and I bought nothing new except the insulating stool. Also that the apparatus I show you to-night, kindly made for me by Mr. A. E. Dean, for this demonstration is the first one made. I have no doubt that as experience in its use is gained improvements will soon follow. I do not apologize for bringing this matter before your notice at this time, when all are so busy with important work for our wounded heroes, soldiers, sailors and airmen, because I know that among these very patients are many who can be relieved of their pain and disabilities by these valuable static modalities alone or in conjunction with or in addition to other methods of treatment, medical, surgical, physical and electrical.

Dr. E. P. CUMBERBATCH, referring to the need for high voltage for the Morton wave current, asked Dr. Batten what was the maximum length of spark obtainable from his machine. A coil would certainly have the advantage over a static machine, in that it would not be affected by the dampness of our climate.

Dr. W. HAMPSON drew attention to the "static breeze," a highly important production of the static machine, and referred to the muscular contraction produced by a moderately rapid stimulation, and to the tetanus and reduction of fluid in inflamed joints that can be obtained with a good influence machine, and remarked that from the demonstration it would appear that it was not easy to produce this form of discharge with the coil.

G. G. BLAKE: I have been particularly interested in Dr. Batten's paper, the more so as I happen to be the inventor of the other machine which he mentioned. If I may be allowed I would like to draw a diagram explaining the method, as it has a great many points in common with that of Dr. Batten. The figure shows the arrangement I employ; any coil can be used with this machine, no special form of

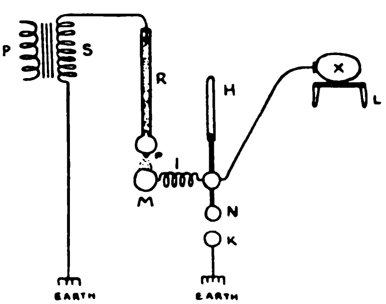


FIG 1

break being required, and it will work in any weather. It gives pure positive and negative charges according to the position of the commutator of the coil. We have proved this to be the case by oscillographs, and spark photographs.

When used in conjunction with a 10″ coil it gives a static brush discharge 5″ long: with larger coils the discharges are proportionately longer.

There is no danger of the patient getting the secondary current of the coil directly as the resistance of the tube R is greater than that of the spark gap employed. This resistance tube contains a solution of alcohol to which is added a very small quantity of water. It is terminated at its lower end with a brass knob, on which is a point P; when the machine is working a brush discharge takes place all the time from this point on to a large brass knob M, which really represents the prime conductor of an ordinary Static machine. When applying the Morton wave current the patient X is placed on an insulating platform L and is connected to the machine, as shown in the diagram. H is an insulating handle by means of which the knob N can be brought at will into contact with the knob K (which is earthed), or it can be set at any desired sparking distance from it. It is practically the same thing as the pendulum idea suggested by Dr. Batten. When the knobs K and N are separated beyond sparking distance, the patient receives a static charge, and is discharged as soon as a spark passes between them, which discharge produces the usual muscular contractions.

I is an inductance the object of which is to damp out any oscillations due to sparking. I had some difficulty in obtaining pure positive and negative charges until I hit on the idea of earthing the free secondary terminal of the coil.

At first I tried valve tubes between the resistance tube and the coil, with the secondary of the coil earthed through a condenser, but I finally got rid of the inverse current by earthing one terminal of the secondary of the coil. All forms of static treatment can be given with this machine, and the one I have works very satisfactorily.

Dr. BATTEN said, in reply: With regard to the length of spark, after all, that is purely a question of voltage. The milliampèrage from the coil is so much greater than from a static machine, and, of course, it is the advantage of a true static machine that one gets up to 800,000 or a million volts, with very little milliampèrage at all. I do not pretend with this coil that I get more than 100,000 volts at the best, it is purely a question of getting a coil built so as to give a very high voltage; with this machine I found that for the static bath one could cut the condenser out altogether, but one had to take care that there was no spark, otherwise the effect was too great. With regard to the static breeze, I cannot get it very satisfactorily—only about a couple of inches long, but I think it is purely a question of increasing the voltage by a suitably wound coil.

With regard to Dr. Hampson's question as to muscular contractions and tissue or tetanic contractions, what I first obtained were tissue contractions in the big muscles, and I was working with an alternating current of about 50 cycles per second, which did not give the muscular contractions, except in the small muscles of the foot or forearm. I got tetanic contractions by very rapid interruptions. In the case of the lady who, I think I may say, was cured and whose case I mentioned in my paper, what were originally produced were not muscle, but tissue or tetanic contractions. By inserting the pendulum both tissue and muscle contractions are easily obtained.

It has been pointed out that with the static machine difficulty is often caused by dampness of climate. And that is a very common drawback, which I hope this new arrangement may do something to overcome. I am very much interested in what Mr. Blake has said. He says that any coil will work with his device. Practically any coil will work with mine, but I have said that the coil with high voltage and little milliampèrage works better. I have nowhere said that this is a new device; I have no doubt it has been carried out before, but I have never heard of the coil being used with a condenser for treatment, and I think that probably the condenser resistance is safer than an ordinary or liquid resistance—safer for the patient, I mean.

It is purely a matter of experiment and a question of working it. I am glad that Mr. Blake has been able to prove that his current is really static, because some of my critics at home have said that it was only a faradic effect. I am sure that some of the effects are not faradic, but really static, though according to our present "electron" theories these terms should become obsolete, and practically the difference between the faradic current and the static wave current is a question of voltage or pace of electrons.

(I.) A MOBILE SNOOK APPARATUS. (II.) A TRANSFORMER FOR HEATING THE FILAMENT OF A COOLIDGE TUBE.

By E. E. BURNSIDE.

(I.) In giving you the following notes on the Snook apparatus (illustrated in Fig. 1.), I do not claim it as new in any essential parts, but at the same time this machine

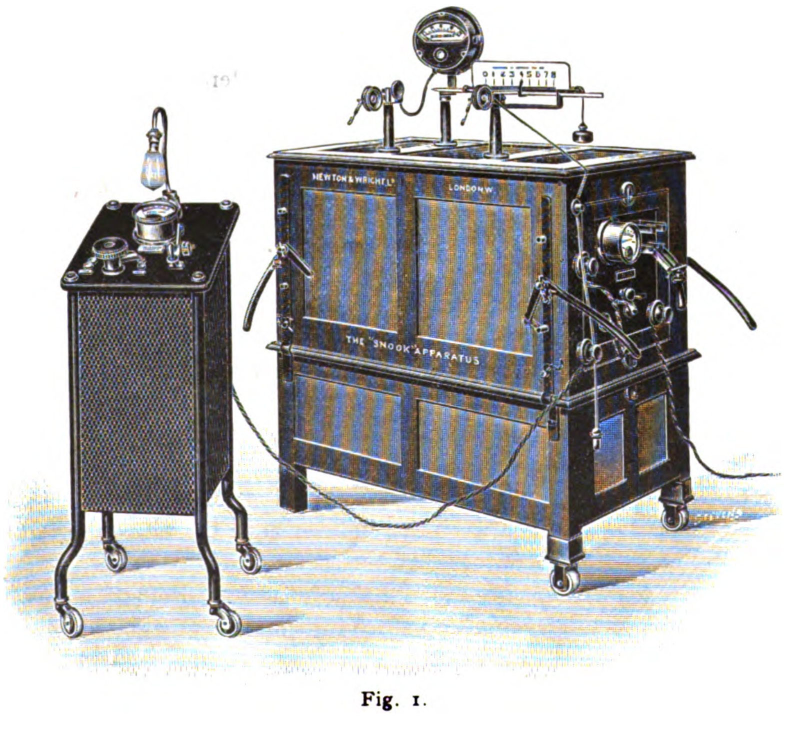


Fig. 1.

in a portable form has only been made possible by the various modifications and improvements which have been introduced into it, and which have been the result of a good deal of practical experimental work. In describing it, one can hardly do so without describing the Snook machine generally, so that if a part of what I propose to say is already familiar to some of those present, I trust they will find some other remarks may be of practical interest. At the present time the transformer is attracting a good deal of attention for military work. In originally adopting the induction coil, the War Office authorities no doubt had good reason, but the Snook principle seems to me to possess such advantages for certain classes, if not all classes of military radiology, that I hope to see it more and more widely used in the future.

The machine consists essentially of three parts—(1) the rotary converter, (2) the transformer, and (3) the high-tension rectifier.

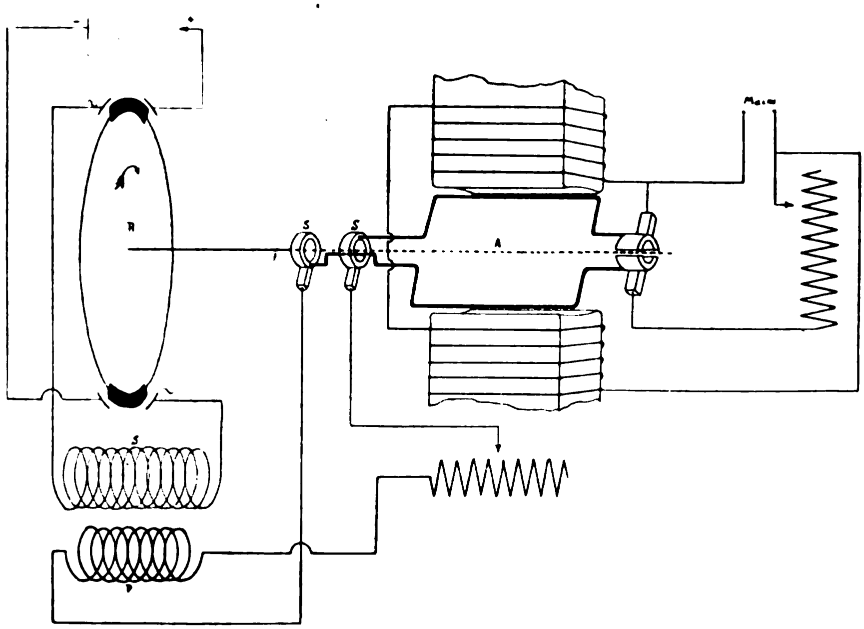


Fig. 2.

Mr. Snook was the first to produce a practical apparatus in which the high-tension rectifier and the rotary converter were built on one axis. Working from the direct current, the mains are connected to the rotary converter through the starting switch, and the alternating current, tapped from the revolving armature, is obtained from the slip rings of the machine. The alternating current thus obtained is lead through the operating switch and control resistance to the primary of the transformer.

The rectifier is interposed between the high-tension terminals of the transformer and the spark pillars of the apparatus, and is so set on its axis that the reversal of the alternating wave, resulting in the final unidirectional discharge, takes place at approximately zero potential. Fig. 2 illustrates the machine diagramatically with its connections above described, and in Fig. 3 the rectifier is shown in two positions at right angles, and I think makes it clear how the reversal takes place.

The original form of rectifier was a much more complicated arrangement than the single disc now used and which is here illustrated.

In the foregoing diagrams I have illustrated a machine made to work from direct current, but when an alternating supply is available a synchronous motor is substituted for the converter for the purpose of rotating the disc. These motors have been greatly improved during the last three or four years and may now be considered perfectly satisfactory and reliable. The synchronous motors used in the Snook apparatus have no slip rings, brushes or commutator, but are self-starting without the aid of these, and when running in synchronism have no tendency to get out of step or to hunt.

Owing to their reliability, an alternating supply main is often to be preferred to a continuous one for X-ray apparatus, which certainly is a reversal of conditions

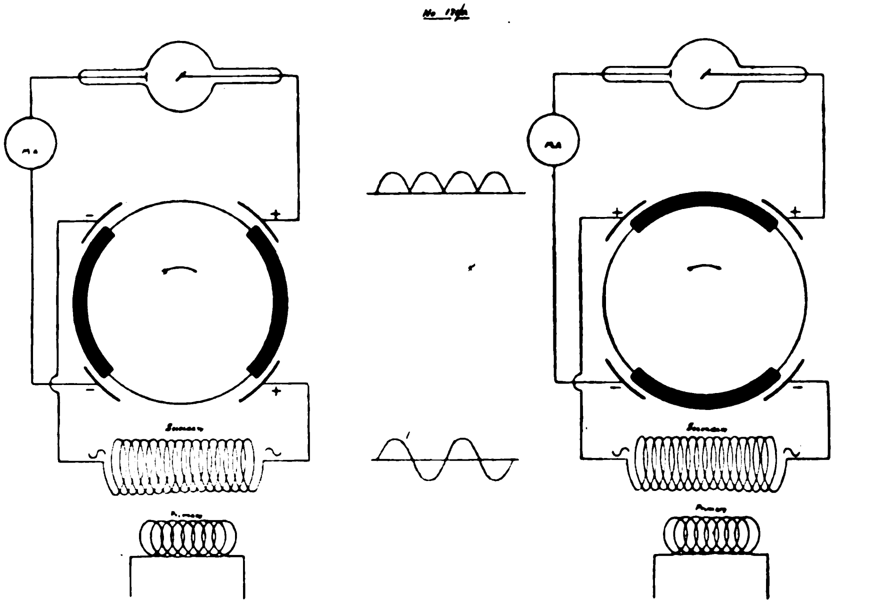


Fig. 3.

existing a few years ago, when an alternating circuit was generally looked upon with good reason as the bug-bear of the radiologist.

The advantages of the Snook apparatus are mainly three:—The wide range of control, the freedom from all inverse current and the ease with which exactly the same conditions can be reproduced from day to day.

The criticism originally levelled against the Snook was that it was more strain on tubes than a coil; this was no doubt due to the fact that the ordinary gas tube was not nearly as good ten years ago as it is to-day, and easily became overheated. The wave form of the current given by the transformers first made, was more or less a true sine curve, as shown at 1 in Fig. 4, and for this reason the tube received a greater proportion of current generating heat than the more sharply peaked wave, characteristic of an induction coil (curve 2). This is, of course, provided the height of the curves was the same in both cases—the heat generated would then be proportional to the area of the wave.

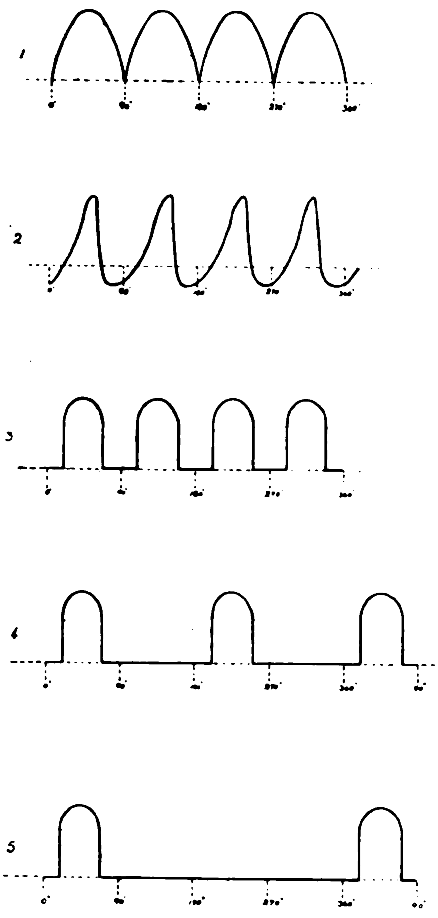


Fig. 4.

Now, the penetration of the X-rays generated is proportional to the potential across the tube, and as in all cases we are dealing with a hetrogeneous beam set up by the varying voltage, a coil will give a smaller proportion of soft rays than a transformer giving a sine curve.

The original Snook used the whole of the sine wave and thus the full heating effect of the current. The part of the curve nearest the zero line certainly did produce a proportion of rays of too low a penetration to be of any value.

To cut out part of the curve nearest to zero potential was not difficult, and was accordingly done by reducing the length of the collecting segments, thus preventing the passage of current to the tube until the voltage had risen sufficiently to produce rays of useful penetrative power. The problem was how to arrive at the right value. This seemed almost impossible to do in any way theoretically, but the result of using different proportions of the wave could be ascertained if careful experiments were made and recorded under practical working conditions. Such a series of experiments were undertaken by Dr. Morton at the West London Hospital some years ago, whilst the machine was being used for routine work extending over many months. Dr. Morton started with long contact arcs and gradually shortened them until the efficiency of his X-ray results began to fall off, indicating that he had gone too far. The proportion of the sine wave thus found has been adopted ever since and is approximately indicated in curve 3. With this wave form Dr. Morton found the X-ray efficiency produced was the best and the heating effect on the tube the least, for any given output.

In this small machine the contact arcs are cut down to a minimum, in fact rather below that indicated by Dr. Morton's experiments. This is to keep down the size of the rectifier as much as possible for reasons of portability.

Assuming the same proportions of the wave were used in all cases, then the maximum spark length obtainable from the apparatus is limited by the diameter of the rectifying disc. This machine is designed for radiography and the spark length limited to 7 inches, enabling a disc 14 inches in diameter to be used. To reduce the weight of the machine its output in milliampères must also be limited, and this direct-current model produces 10 milliampères through a normal tube only.

I will refer in passing to the other diagrams, curves 4 and 5, although they have

no reference to the machine here to-night. They indicate the wave of current which can be produced by what has been called a wave selector. It is an arrangement connected in the primary circuit of the transformer enabling every alternate impulse of the current to be cut out, or, alternatively, three out of every four impulses, at will. This gives the operator the choice of using two slower rates of pulsations through the tube, in addition to the normal rate, and is equivalent to running the interrupter of an induction coil at a slower rate.

This model of the Snook apparatus has been designed to produce a portable transformer to work with any good tube as at present used, but I have not yet mentioned the Coolidge tube in connection with it.

Owing to the Coolidge tube being a practically perfect vacuum, it is possible to use it on an alternating current without any rectifier, but if so used the current it is possible to pass through it is limited. A Coolidge tube will only rectify while the temperature of the focal spot on the anticathode is lower than the temperature of the hot cathode filament, and for this reason a unidirectional current is necessary in practice with the standard Coolidge tube.

At our last meeting, Mr. Darnell showed a new pattern Coolidge tube in which the focal spot was so rapidly cooled that it would work continuously on an alternating current without any outside rectifier.

Owing to the rectifying property of this new Coolidge tube it is possible to work it direct from a high-tension alternating current transformer, as Mr. Darnell also showed. Such an apparatus is, of course, smaller and more portable than this Snook machine, but it will work a Coolidge tube only, whereas this apparatus will work any ordinary tube. The transformer of this Snook apparatus is very suitable, as it stands for working this new Coolidge tube, and Mr. Darnell said he would like to see this made up into a compact alternating current apparatus similar to the American-made one which we saw last month. I hope to show a British-made apparatus on these lines here before long.

(II.) Reference to the Coolidge tube brings me to the second apparatus I have to show to-night, namely, a transformer for heating the cathode filament, Fig. 5. This transformer is, I believe, the first finished apparatus for the purpose made in this country. The winding of it is very similar to the small alternating current transformers used for cautery work, as the filament of a Coolidge tube takes about 4 ampères at 12 volts to bring it up to the correct temperature. This low voltage circuit, when in use, is directly connected to the high-tension cathode terminal of the tube, and therefore the 12-volt winding is highly insulated from its primary winding, just as though it were the secondary of an ordinary induction coil. All users of the Coolidge tube know how fine is the adjustment of the filament current, 0·1 of an ampère making a very considerable difference to the milliampèrage which the tube will allow to pass.

In this transformer the adjustment is effected by connecting a choking coil, having an adjustable iron core, in series with the primary winding. The core is arranged to move in and out by a screw adjustment operated by a turning knob, and owing to the coil being in the primary circuit and highly insulated from the secondary it can be mounted on the switch trolley of the X-ray machine. This is very convenient, as it enables both the penetration of the tube and the milliampèrage to be controlled as desired from the switchboard. A scale with indicator shows the adjustment of the core at any time, enabling any desired setting of the tube to be reproduced from day to day. This scale is an advantage in accurately

registering results, as it indicates smaller differences in the current than can be readily observed on the ammeter in the filament circuit of the tube. The transformer, of course, requires an alternating current and when a direct current supply only is available the apparatus includes a small rotary converter. The apparatus I have

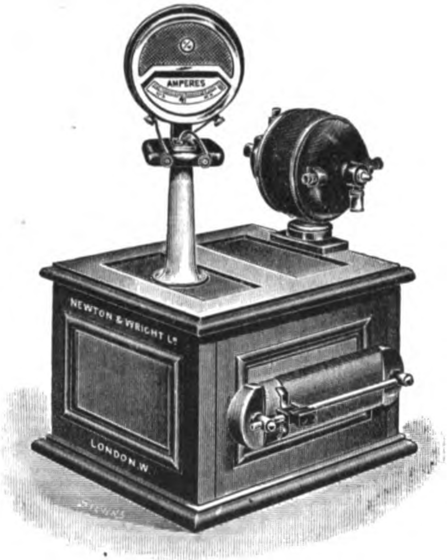


Fig. 5.

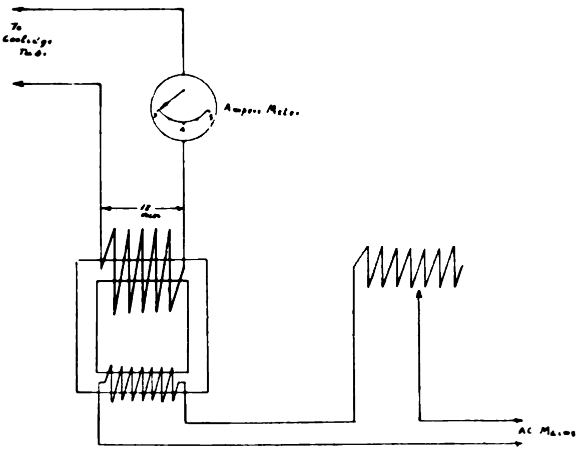


Fig. 6.

here works in this way from the 240-volt direct-current mains. Fig. 6 shows a diagram of connections, but the adjustment here indicated is a rheostat instead of the choking coil described above.

NEW MEMBERS ELECTED BY BALLOT.

Name.	*Proposer.*	*Seconder.*	*Date of Election*
RUSSELL SODEN FELGATE, Chemist, Briardene, Northwood, Middlesex	G. W. C. Kaye ...	Sidney Russ ...	Jan. 1st, 1918
JOHN NAISH GOLDSMITH, Ph.D., M.Sc., Consulting Chemist, 67, Chancery Lane	G. W. C. Kaye ...	Sidney Russ ...	Jan. 1st, 1918
RALPH WILLIAM KENNEDY, Assistant Inspector, Aeronautical Inspection Directorate, 31, Gartmoor Gardens, Wimbledon Park Road, S.W.19	G. W. C. Kaye ...	Sidney Russ ...	Jan. 1st, 1918

Name.	*Proposer.*	*Seconder.*	*Date of Election*
WILFRED E. GUTTENTAG, Mining Engineer and Petroleum Technologist, 4, Clement's Inn, W.C.2 ...	G. W. C. Kaye ...	Sidney Russ ...	Jan. 1st., 1918
CLIFFORD C. PATERSON, Electrical Engineer, 10, Walpole Gardens, Strawberry Hill, Middlesex ...	W. F. Higgins ...	Sidney Russ ...	Jan. 1st, 1918
WALTER MAKOWER, M.A., D.Sc., Lt. R.N.V.R. (University Lecturer), Imperial College of Science and Technology, R.N.A.S. w.1. Laboratory	Sidney Russ ...	J. W. Nicholson ..	Jan. 1st, 1918
WILLIAM H. PERROW, Post Box 342, Cape Town	T. P. Pask	Geoffrey Pearce	Jan. 1st, 1918
V. E. A. PULLEN, D.Sc.Lond., Woolwich Arsenal	Robert Knox ...	W. F. Higgins ...	Jan. 1st, 1918
DR. HOWARD, Croydon	C. E. S. Phillips ...	Robert Knox ...	Jan. 1st, 1918
ERIC J. WARD WATKINSON, X-ray and Electrotherapeutic Engineer, 8, Thornhill Crescent, London, N.1...	H. Annesley Eccles, M.D.	John Morison, M.D.	Jan. 1st, 1918
ALISTAIR MACGREGOR, M.D., Electrotherapeutist, 14, Welbeck Street, W.1	Dr. Cumberbatch ..	Robert Knox ...	Jan. 1st, 1918
CAPTAIN D. V. MYERS, M.B., Ch.B., Radiologist, No. 2, New Zealand Hospital, Walton-on-Thames. Home Address, Otago, New Zealand	Major Stowe ...	Robert Knox ...	Jan. 1st, 1918
E. W. G. WESSON, 1, Cambridge Road, Harrogate	Robert Knox ...	Geo. H. Rodman	Jan. 1st, 1918
FRANCIS W. WILLCOX, 77, Upper Thames Street, E.C.4	Robert Knox ...	Sidney Russ ...	Jan. 1st, 1918
CAPTAIN BOWIE, R.A.M.C., Radiologist, 3rd London General Hospital	Sir J. Mackenzie Davidson ...	Robert Knox ...	Jan. 1st, 1918
LESLIE M. FORSYTH, Assistant Radiologist, No. 1 South African General Hospital, Abbeville, A.P.O., S.1, B.E.F.	Robert Knox ...	Geoffrey Pearce ..	Jan., 1st, 1918
GEORGE RUDORF, Ph.D., B.Sc., Technical and Consulting Chemist, 52, Cranley Gardens, Muswell Hill, No.10	G. W. C. Kaye ...	Sidney Russ ...	Feb. 5th, 1918
JOSEPH C. KERNOT, D.Chem., B.Sc., Royal University of Naples, "Cusop," Vineyard Hill Road, Wimbledon, S.W.19	G. W. C. Kaye ...	Sidney Russ ...	Feb. 5th, 1918
JAMES MCKAIL. M.A., M.B., Ch.B., 10, All Souls' Avenue, Harlesden, N.W.	Robert Knox ...	G. W. C. Kaye ...	Feb. 5th, 1918
FRANK LEOPOLD BAKER, 78, Swanston Street, Melbourne, Australia ...	F.W.Watson Baker	Geoffrey Pearce .	Feb. 5th, 1918
JAMES PATRICK TRAINER, Ocean House, Moore Street, Sydney, Australia .	Geoffrey Pearce ...	Robert Knox ...	Feb. 5th, 1918
JAMES GEORGE EDWARDS, M.B., M.S., 279, Macquarie Street, Sydney, Australia	Geoffrey Pearce ...	Robert Knox ...	Feb. 5th. 1918
IAN HOWDEN, M.D.(Edin.), F.R.C.S. (Edin.), 6, Cambridge Terrace, Dover	H. Trevelyan George	Robert Knox ...	Feb. 5th, 1918
ISOBEL MITCHELL, M.B., Ch.B., B.Sc., Midland and Nottingham Eye Infirmary, The Rope Walk, Nottingham	W.Carrick Allan ...	Arthur Schiff ...	Feb. 5th, 1918
EVIE A. ROBERTSON, M.B., Ch.B., Hackney Infirmary, Homerton, E.9	W. Carrick Allan ...	Arthur Schiff ...	Feb. 5th, 1918

NEW BOOKS.

Radiography and Radio-therapeutics. Vol. II. By ROBERT KNOX, M.D. A. & C. Black, Ltd., Soho Square, London, W.

In our last issue we announced the publication of Vol. I. of this valuable contribution to the practice of radiology. Vol. II. is now to hand, dealing with the treatment of disease by X-rays and radium. It is of even greater value than Vol. I. in that it deals with the actual application of the appliances there detailed. In a masterly introductory chapter the whole subject is reviewed and the action of radiations upon normal tissue and morbid growths is fully discussed, the note concludes with a reasonable account of the dangers attendant upon the use of X-rays and radium. Some forty pages are devoted to the description of apparatus, and instruments for measuring dosage and the remainder of the book contains specified applications of radiations in the treatment of disease, the concluding pages dealing with the use of radiation in plastic surgery of the face and jaws, which bring home to one the value of the recent developments when applied to some of the saddest effects of the present war.

The book also contains a useful glossary of the terms used in medical electricity.

An X-ray Atlas of the Skull. By H. A. RUSSELL GREEN, M.B., B.S. (Lond.), M.R.C.S. (Eng.), Capt. R.A.M.C. (T.). With five coloured plates and a table showing relations between displacement of shadows and distance of bodies throwing those shadows. Longmans, Green and Co., 39, Paternoster Row, London. Price 10/6 nett.

The author's object has been to produce a series of diagrams showing what may be seen or located in the dry skull when radiographed from different angles. The method adopted has been to increase the opacity of certain parts by outlining the sutures with wire, covering the structures with tinfoil injecting the sinuses with a mixture of bismuth and paraffin wax, and in the fresh state by injecting the blood vessels with mercury. These processes have been confined largely to one side of the skull. so that throughout the Atlas one half appears as a diagram and the remainder as a more or less untouched print.

A very simple method of localization is given, by which it is possible to accurately locate foreign bodies in skull, the apparatus needed is not elaborate. The coloured diagrams and radiographs will doubtless be found of great value, especially in hospital practice, and are a very fine production.

Localization et Extraction des Projectiles. Par L. OMBRÉDANNE ET R. LEDOUX-LEBARD. Second edition. Masson et Cie, Editeurs Libraires de L'Académie de Médecine, 120, Boulevard Saint German, Paris, vi.

This very practical work of some 300 pages, written in the midst of the activities of the war, will be found of great assistance to French doctors who propose taking up the practice of X-rays. The names of the authors are sufficient to guarantee soundness in the treatment of the subject. The work is roughly divided into three parts. The physics of the production of X-rays, the theory of localization and the extraction of foreign bodies. A very large number of illustrations are given both diagrammatic and radiographic. The exceedingly lucid description of the process, aided by the pictures, is calculated to give a rapid and sound knowledge of the subject.

Précis de Radiodiagnostic Technique et Clinique. Par Le Dr. JAUGEAS, with a preface by M. Le Dr. Béclére. (Second edition).—Masson et Cie, Editeurs, 120, Boulevard Saint German, Paris.

This work, well known to French readers, of some 550 pages, has been brought up-to-date. It treats very exhaustively of the subject of X-rays and the practice of radiology. The preface by Dr. Béclére that appeared in the first edition is included, together with that of the second by the author. The work commences with an historical summary in which the early researches of Crooks, that led up to Röntgen's discovery, are described and illustrated. The book is divided into three parts, the theory, instruments and apparatus, the radiodiagnostic technique as applied to the normal, and the clinical applications. In addition to a great many illustrations there are sixty three half tone plates, chiefly radiographs. The subject is treated in a masterly manner and the work will doubtless be regarded as a standard of reference in the French language.

Exploration Radiologique des Voies Urinaires. Lithiases et projectiles de Guerre. Par Le Dr ARCELIN, 123 Figures et Planches hors texte. Masson et Cie, Editeurs, 120, Boulevard Saint-German, Paris.

This special and important branch of radiography is very enhaustively treated by the author, the work occupies 175 pages and is fully illustrated by diagrams and radiographs; some extraordinary cases of foreign bodies in the bladder are described. The main portion of the work was completed before July, 1914, but the war, although delaying publication, has enabled the author to add a special chapter dealing with the radiographic examination and localization of war injuries that is of special value in the present circumstances.

NOTES.

A NEW "SHADOW MEAL."

Messrs. Allen & Hanburys, Ltd., have placed on the market a prepared barium meal that will be found of great convenience as a diagnostic agent in diseases of the stomach and intestines; the preparation is sold under the name of UMBROSE and is the result of experiments carried out by James Metcalfe, M.D., the object being to produce a palatable and opaque medium that can be quickly and easily prepared. It consists of 75 per cent. barium sulphate with 25 per cent. pabulum of cocoa, arrowroot, desiccated milk, etc., ground together into an impalpable powder. The preparation for use is so simple that it can be carried out in a few minutes in the X-ray room, and is thus always available at short notice.

A SIMPLE CONSTRUCTION FOR A CONDENSATION PUMP.*

By W. C. BAKER.

The construction of the mercury condensation pump described below is so simple that it may be followed even by those of the most limited proficiency in the art of glass-blowing.

A bit of fine quill tubing is joined to the end of a "1¼-inch" test tube, as shown in Fig. 1, *a*. A small enlargement is blown in this about a centimetre from the test tube, and the quill is drawn off to a blunt point a centimetre farther out. The end of the test tube is then cut off so as to leave 5 or 6 mm. of parallel wall. The piece thus made will be referred to as the dome.

Next two "1½-inch" test tubes are selected, such that one will slide inside the other, leaving not more than 2 mm. difference between the inner diameter of one and the outer diameter of the other. The smaller of these is drawn down and cut as shown in Fig. 1, *c*. This piece will be spoken of as the chimney.

Two bits of iron wire, of diameter about 1 mm. are next twisted together as shown in Fig. 1, *b*. The outer vertical pieces should rest snugly against the inside of the chimney and the hooks should bear on its upper edge, while the central rod is to be cut so as to hold the dome with its lower edge about 5 mm. below the level of the top of the chimney (see Fig. 2).

The chimney is now slid to the bottom of the larger test tube and a point marked on the outer tube about 15 mm. above the line where the base of the chimney rests. Here a side tube is attached and below it is made a local enlargement, as shown in profile in Fig. 1, *d*. A section on the dotted line of Fig. 1, *d*. is given in Fig. 1, *e*. This passage is necessary to allow the condensed mercury to flow back freely under the base of the chimney.

The dome is now fitted with a distance piece to hold it central in the tube. This is made of iron wire and is shown at *f* in both figures. It is tied on with finer iron wire. The enlargement in the quill of the dome is to prevent the distance piece from sliding off during the adjustment of the condenser. The assembled dome and chimney are lowered to place in the bottom of the

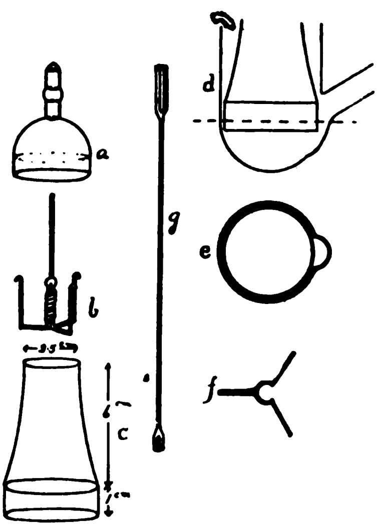


Fig. 1.

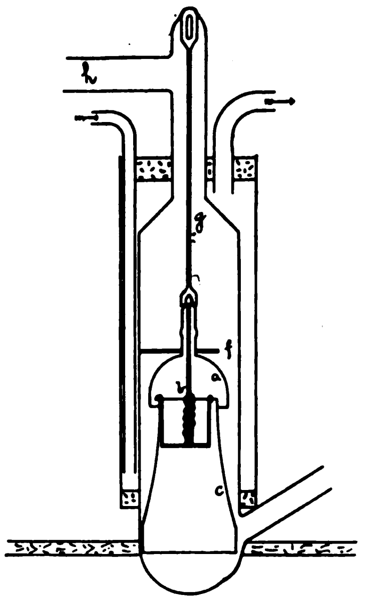


Fig. 2.

* *Physical Review*, Vol. x., No. 6, p. 642 644, December, 1917.

larger test tube and the top is drawn down and sealed to a bit of wide quill tube, as shown in Fig. 2.

The condenser is made from a length of " 2-inch " tube, corks being used at both ends. Sealing wax does well for all the joints of these corks except the lower inner one, where the heat from the condensing mercury would soften the wax. It was found best to leave this cork rather loose on the inner tube and then to caulk the joint with thin strips of ordinary electrical insulation tape pushed in with the thin blade of a small penknife. If this lower joint does not prove to be quite tight, a little mercury may be put into the condenser to a depth of about 1 cm. This is sufficient to prevent any leakage of the cooling water.

Tubes for the entrance and exit of water are as shown in Fig. 2.

Next, a tee (*h*) is attached to the upper quill tube and a support put down on top of the dome, to prevent it rising during the action of the pump. This piece, shown in Fig. 1, *g*, is made by drawing down to a thin solid rod a bit of thick walled quill tube.

Mercury is used sufficient to cover the base of the chimney to a depth of 3 or 4 mm.

A hole is cut in the middle of a square of stout asbestos board so as to allow the pump to project below to the level of the bottom of the chimney and the bare flame of a small Mecker or Bunsen burner is allowed to play directly on the glass (after warming up, of course). Care must be taken that the pump does not project so that the flame touches glass not covered with mercury..

These pumps are easily made and work very well with a Fleuss pump for the fore-vacuum.

Physical Laboratory, Queen's University, Kingston, Ont., July 15, 1917.

ABSTRACTS.

68. *New Secondary Radiation from Canal Rays.* M. WOLFKE. (Phys. Zeits. 18, pp. 479—483, Oct. 15, 1917. Paper read before the Scwheiz. Naturforsch. Gesell., Zurich, Sept., 1917.)—Some years ago Chadwick and Russell [Abs. 489 (1914)] showed that α-rays can excite the characteristic γ-radiation of the heavier elements. The present paper contains a description of experiments indicating that canal rays can excite characteristic X-radiation in a similar way. In the case of tin and lead it is shown that a penetrating radiation is produced when bombarded by canal rays. This effect was observed photographically and the X-radiation proved to be characteristic of these elements. In the case of lead, a value of the wave-length of the radiation was determined at a particular value of the discharge voltage.

On the basis of Einstein's quantum law it seems probable that the new effect accounts for the production of the lines in the L-series of both elements. A. B. W.

69. *X-ray Spectra of Isotopic Elements.* M. SIEGBAHN AND W. STENSTRÖM. (Comptes Rendus, 165, pp. 428—429, Oct. 1, 1917.)—It is known, according to the work of Rutherford and Andrade, that the γ-ray spectra of RaB and RaC show a marked agreement with the X-ray spectra of their isotopes. On account of the difference in the method of measurement of the wave-lengths in the two cases, it is difficult to form an estimate of the accuracy of this agreement. It seems possible that the actual difference may be less than the limits of error in the experiments. A comparison of the X-ray spectra of radio-active substances with the X-ray spectra of their isotopes appears to be more than the analogous study of the X-ray spectra of different isotopes. Thus a study has been made of the X-ray spectra of the isotopes lead—RaG ; RaG existing in quantities sufficiently pure for a determination of its atomic weight.

The two spectra were obtained on the same plate under identical conditions, and measurements made of all the lines of the " L " series and the strongest lines (α, β) of the M series.

As a result of the measurements the authors conclude that the wave-lengths of the X-ray spectra of the isotopes lead-RaG agree to within $0{\cdot}0001 \times 10^{-8}$ cm. approximately. A. B. W.

97. *Spark-lengths in Gases and Vapours.* R. WRIGHT. (Chem. Soc., J., Trans. 111, pp. 643-649, July, 1917.)—The comparative study of spark-lengths in different gases and vapours is rendered difficult by the circumstance that what is ordinary temperature and pressure for gases may be extreme conditions for vapours. The author first attempted to compare vapours at their boiling-points, but he was troubled with condensation on the electrodes. He therefore decided to keep the two spark-gaps of air and the substance under test, at the same temperature so as to have the same number of molecules per unit volume ; when the spark is produced in a closed vessel, heating the gas has no influence on the spark-length, and the volts required are independent of the temperature ; in an open vessel, in which the gas can expand, rise of temperature (or diminution of the gas pressure) increases the spark-length corresponding to a certain p.d. A gap of 20 mm. at 100°C. corresponded with a gap of 15 mm. at 18°, and a gap of 20 mm. at 183° with one of 5 mm. at 18°. The electrodes of his standard air-gap were brass spheres of 5 mm. adjustably mounted in a vertical glass tube 15 mm. in diam., surrounded by a vapour-jacket ; the other tube was similarly arranged, and the two tubes were electrically in parallel with an induction coil. By the aid of a third gap the potential was varied ; this gap, closed to start with, being gradually widened during an experiment. The results differed frequently by 10 per cent. and more, and the spark-length corresponding to an air-gap of 20 mm. was not $\frac{2}{3}$ of that with a 30-mm. air-gap, as it should have been with parallel curves of spark-length and potential. The curves intersected in fact sometimes ; thus carbon dioxide proved a better insulator than air at low temperatures, but a better conductor at high potentials. On the whole,

however, for series of chemically comparable substances an increase in molecular weight is accompanied by an *in*crease in insulating power (*de*crease of spark-length). Thus methane CH_4, methyl chloride, CH_3Cl, methylene chloride, CH_2Cl_2, chloroform $CHCl_3$, carbon tetrachloride CCl_4, give at 100° with an air-gap of 30 mm., spark-lengths of 29, 24, 9, 5, 1·5 mm. Other homologous compounds and also CO_2, SO_2, CS_2, H_2S showed similar relations. H. B.

165. *X-rays and the Theory of Radiation.* C. G. BARKLA. (Roy. Soc., Phil. Trans, 217, pp. 315-360, Aug. 29, 1917.)—Bakerian Lecture).—[Further to Abs. 55 (1917)].—Experiments on (a) X-ray fluorescence (excitation by a primary X-radiation); (*b*) corpuscular radiation; (*c*) ionisation; (*d*) absorption, point to the existence of new series of characteristic radiations. All these methods show that under the usual conditions light elements emit characteristic radiations of moderate penetrating power, and that the higher the atomic weight of the element the more penetrating is its radiation. These radiations are much harder than those of the K-series of the light elements, so that they must constitute a new series of characteristic radiations, which is called the J-series since there is no evidence of an intermediate series. The mass absorption-coefficients for the radiations from nitrogen to sulphur have been measured in Al, and are found to vary from about 2·5 to 1·75. E. A. O.

202. *Oscillatory X-ray Tube for applying very High Doses to Deep-seated Lesions.* (Archives d'El. Médicale, 25. pp. 551-554, Dec., 1917.)—The difficulty of applying sufficiently intense radiation to deep-seated lesions without injury to the healthy skin has been a problem which lately has excited much interest. Attempts have been made to overcome the difficulty by moving the tube to two, three, or a very large number of different positions instead of applying the whole dose from any one point. This method is unsatisfactory when done by hand, because of the waste of time and the uncertainty as to whether the max. effect is produced at the point required. The present apparatus is so arranged that the tube is displaced automatically above the patient by a mechanical apparatus, which is in principle like a large metronome having a horizontal arm carrying the tube. By this means the tube moves in an arc and the part upon which the rays are required to act remains always along the normal. In this manner the radiations are spread over a comparatively large area of the surface while they are concentrated upon the deeper parts. There still remains the fact that even with such an arrangement some parts of the surface are subjected to much more intense radiation than others, but this has been annulled by suitable screens and by regulating the velocity of movement of the tube along the arc. A. E. G.

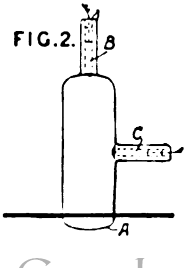
203. *New Method of extracting Foreign Bodies, using a Radioscopic Screen. Method of Connected Shadows.* MAZERES. (Comptes Rendus, 165, kp. 397-398, Sept. 17, 1917.)—This method appeals by its simplicity. No special apparatus is required beyond the bulb, screen, and a pair of pincers. The point of incision being chosen, the tip of the pincers is placed in the incision made in the skin and the screen is put in position. The object then is so to arrange the pincers that the prolongation of its shadow on the screen shall cut that of the projectile for two different positions of the builb. When this has been done the direction of the pincers gives the line of incision leading to the foreign body. The method of procedure when the shadow does not fall in the correct line is dealt with in detail. A. E. G.

204. *Localisation of Foreign Bodies by the Tauleigne-Mazo Radiostereometer.* (Archives d'El. Médicale, 25. pp. 463-469, Oct., 1917.)—The apparatus furnishes measurements of the depths as well as those of size, in addition to anatomical localization. Being based on a different principle, it corroborates results obtained by other methods. The radiostereometer consists essentially of a stereoscope with glass on two sides, and a network of lines or a micrometer for measuring purposes. Details of the stereoscope and measuring apparatus are given as well as the method of employing the micrometer. (See also Abs. 1372 (1917).) A. E. G.

Abridgments of recent Patent Specifications bearing upon the subject of X-rays and Allied Phenomena.—Compiled for publication by H. T. P. GEE, *Patent Agent, Associate I.E.E.*, 25, *Victoria Street Westminster, London, S.W.*1, *any at* 70, *George Street, Croydon.*

102,101. *Röntgen-ray Apparatus.* ROBINSON, W. J., 20, Varnum Street, West Lynn Massachusetts, U.S.A. June 15, 1917.—A tube preferably of cylindrical form has both electrodes external. One electrode C may be at the side of the tube and the other B at the end. In the opposite end of the tube there may be a window A of lime glass or other glass transparent to X-rays, the rest of the tube being either of lead glass or lime glass. The tube itself serves as anti-cathode. Each electrode may be a body of mercury or amalgam, retained if necessary by a vulcanized stopper, within a re-entrant tube situated in a side-tube. The electrodes may be 3-4 in. apart, and the tube may be of such size that it can be carried in the pocket. No vacuum-regulator is necessary. In use, the end of the tube may project through a hole in a protecting screen as shown.

FIG. 2.



110,774. *Gases and Vapours, treating electrically.* GALLOT, G. A., 9, Rue Méchain, Paris, and POUSSIN, P. M. N., 29, Rue Etienne Marcel, Pantin, Seine, France. Sept. 28, 1916.—In apparatus for separating dust or liquid particles from gases and vapours, comprising a tubular perforated electrode and an inner electrode, the distribution of the electric field is improved and sparking at the ends of the electrodes is checked by placing insulating material between the electrodes at their ends, or by tapering or rounding off the ends of the inner electrode when this is cylindrical. Efficiency is thus increased, and the use of longer electrodes and higher electric pressures facilitated. The inner electrode may be a wire *g*, surrounded near the ends of the outer electrode *d* by insulators *i*, i^1 of glass, mica, ebonite, etc., which may be mounted on the wire or carried by bridges across the outer electrode. The outer electrode may be cylindrical throughout or flared at its ends. In the multiple arrangement shown, the gas traverses the outer electrodes from a common settling chamber *a* and pipe *b*. Dust, etc., passes through the perforations in the outer electrodes into spaces *f*. The wire electrodes are supported by two rods, *k*, k^1. In another arrangement, the inner electrode is a tubular body with hemispherical ends. An electrode of similar outline may be constructed of metal strips projecting radially from a cylindrical body which has circumferential ribs to check the flow of gas between the strips. At their ends, the strips are bent to meet at two points in line with the axis of the cylindrical body. A number of wires may be connected at two end points and spread by transverse discs to form a cylindrical cage with conical ends. A wire-gauze cylindrical electrode is mentioned. The electrodes may be vibrated to keep them clean. They may be charged by electrostatic machines, induction coils with rotary commutators and valves of the disc-and-point or rarefied-gas type, or static transformers with synchronous commutators or incandescent-cathode rectifiers. Condensers are placed in parallel with the separator. The apparatus may be used for removing smoke, poisonous dust, lead oxide, zinc powder, cement, plaster, flour, or kaolin from air, or carbon from gases in porcelain furnaces.

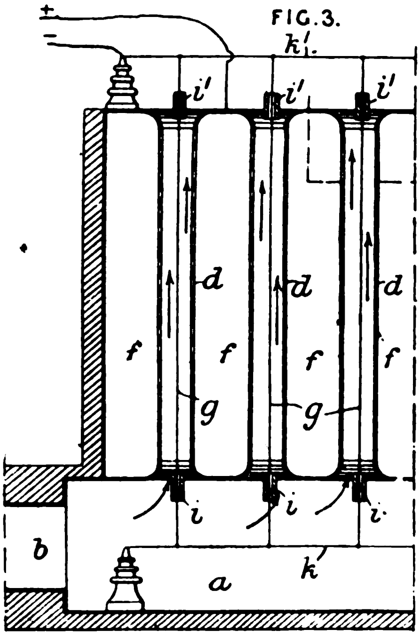


FIG. 3.

111,570. *Röntgen-ray Apparatus.* HOGAN, G. R., 1501, South Eighth Avenue, Maywood, and MACLAGAN, H. P., 353, North Washington Street, Park Ridge, both in Illinois, U.S.A. Dec. 22, 1916.—A valveless X-ray tube is connected directly to a current source producing an alternating pressure of symmetrical wave form and only of sufficient magnitude to cause unidirectional current in the tube. The pressures at which the tube becomes conductive in one or both directions vary with its construction ; they may be 80,000 volts and 105,000-110,000

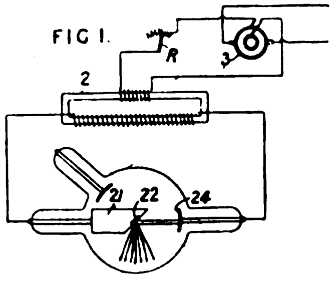
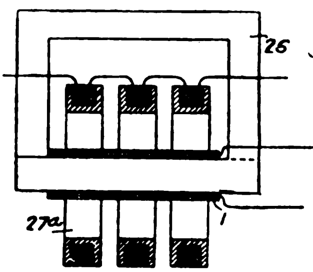


FIG 1.

FIG 4.


volts respectively. In the tube shown in Fig. 1, the anti-cathode is a tungsten disc 22 let into the bevelled end of a copper cylinder 21. A separate anode, if provided, is preferably not connected in circuit. The cathode 24 is of aluminium. The current source may be a transformer 2 having its primary winding connected through a regulator R with a rotary converter 3, a motor-generator, or a second transformer, or directly with supply mains. Fig. 4 shows a suitable construction of the transformer 2, Fig. 1. The primary winding 1 is adjacent to the closed laminated core 26, while the secondary is wound on separate insulating spools 27^a spaced apart from each other and from the core. The transformer is preferably immersed in oil.

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SILVANUS P. THOMPSON MEMORIAL LECTURE.

By Prof. Sir ERNEST RUTHERFORD, F.R.S.

I feel it a great honour to be asked to give the first of the annual lectures you have instituted in memory of the late Professor Silvanus P. Thompson, the first President of your Society. I recognise that the Röntgen Society has been very generous in its treatment of one who, although an honorary member, has been so remiss in attending your meetings, but I hope I may plead in extenuation my misfortune in living in a distant city. I can, however, truthfully say, that, if your journal is a faithful record of your lively discussions, I have kept closely in touch with your doings and have derived much interest and benefit from my reading. I sometimes think that a distant observer like myself may see the usefulness of your Society in truer perspective than the regular participant in your meetings, and I am in consequence emboldened to say that in my opinion the Röntgen Society, quite apart from the recognised value of its scientific and technical contributions, performs another exceedingly useful function in forming a common meeting ground of representatives of widely different sciences. It is one of the few societies in the country which is catholic in its membership, including members of the medical profession, engineers, men of pure science and scientific amateurs, banded together by a mutual interest to exchange views and to promote the usefulness of your Society. With good fellowship, such an admixture cannot fail to have a beneficial and broadening effect on all—not least, I am sure, on the particular group to which I belong—and cannot fail to promote a better understanding and appreciation of each other's aims and efforts—a form of charity of which some of us are sadly in need.

I am sure we can all agree that the Röntgen Society made a very fortunate choice in selecting Professor S. P. Thompson as their first President, for he was a man not only distinguished as a teacher, investigator and writer on technical science, but was in addition greatly interested in the advance of pure science, especially in the domain of optics. This is well shown by his contributions on Light and by that excellent book " Light, visible and invisible," published in 1897. It was his interest in all types of radiation that led him to make experiments on X-rays immediately after their discovery and, I understand, he was one of the first to obtain X-ray photographs in this country Subsequently he was able to show that the efficiency of X-ray tubes was increased by the use of heavy elements like platinum and uranium as anticathode and made other researches on the effect of a magnetic field on the discharge in a vacuum tube. With his interest in pure science and its application, it must have been a gratification to him to become your first President and to guide

your infant steps along the path of progress. Apart from his presidential address, his most notable contribution to the Society was an account of his experiments on the physiological effect on the head of a powerful alternating magnetic field, serving as an illustration of the catholicity of his scientific interest and his versatility.

It is not for me to appraise the value of his contributions to technical science, but I would like to express the debt which I, and I am sure many other scientific men in this audience, owe to his admirable text books. I gained my first knowledge of electricity from "Elementary Lessons," that remarkable and perennial book which has served to interest and instruct scientific youth and even middle age in all parts of the world. This work is marked by that clearness, simplicity and charm which is so characteristic of all his writings and lectures. If I was suckled, so to speak, on elementary lessons, I cut my first teeth on dynamo-electric machinery, and I can well recall the strong impression left on me by the exceedingly clear, simple and logical statement of the essentials of a complex subject. In this connection, I call to mind a conversation I had some ten years ago in New York with an editor of a well-known technical journal, *apropos* of the rapid growth of electrical engineering in U.S.A. He remarked on the eagerness and almost excitement with which the publication and first arrival of S. P. Thompson's "Dynamo-electric Machinery" was awaited in his country, and the strong influence this book had excited in leading to a correct understanding of the fundamental facts and theories on which the science of electrical engineering is based.

In reading again the admirable and presidential address of Professor S. P. Thompson to this Society in 1897, before a brilliant audience and which, we are told, occupied forty minutes, one cannot but recall the exciting atmosphere of that time and the extraordinary interest that was aroused in the lay and scientific mind alike by the discovery of the Röntgen rays. Naturally in his address, prominence was given to the medical application of those rays for the advancement of which the Röntgen Society was primarily founded, and for which it has done such admirable work. But an interesting account was given also of the ideas at that time of the nature and origin of the new rays—ideas that have in the main received complete verification in recent years.

It was difficult even at that time to foresee the great field of usefulness in medicine that has since been opened up by this discovery—an account of which has been so ably given by your President, Captain Kaye, in his recent address. The ground in this direction has been so completely covered by him that there is nothing of interest left to me to add, except to express my pleasure in reading his vigorous address.

I hope, however, it may prove of some interest to your Society to outline, of necessity very briefly, the remarkable scientific development that either directly or indirectly resulted from the discovery of X-rays. The outbreak of war caused an almost sudden stop in the great tide of scientific advance in this country and the prolonged lull affords a suitable opportunity to look back and to view in some perspective the great scientific advances that have been made.

Undoubtedly the discovery of this new type of radiation marks the beginning of a new epoch in physical science which has resulted in a revolution of our ideas on the nature of matter and electricity almost as marked as that produced by the theory of evolution in biology. It is a period of pioneer advance over a new and fertile territory with the almost daily discovery of new and interesting facts and the

gradual unfolding of new and bold fundamental ideas. The two decades between 1895 and 1915 will always be recognised as a period of intense scientific activity which has no counterpart in the history of physical science.

It has been a time of great experimental activity and also of scientific speculation, but not as a whole of rank speculation, for the main ideas which governed this advance have been exceedingly simple though very fundamental and have been shown in most cases to have a solid foundation in fact. The rapidity of the advance brings home in a vivid and impressive way the extraordinary power of the scientific method of hypothesis and experiment to attack novel and at first sight insuperable difficulties. One small gain in knowledge or improvement in technique in one direction leads to an advance in another, and before the ordinary observer has grasped the situation, there is a rapid advance and successful attack of what appeared to be an almost impregnable position.

The writer had the good fortune to begin his researches in the Cavendish Laboratory in October, 1895, and has been so occupied in endeavouring to keep abreast of the line of advance that there has been little time or opportunity to stop and form a just appreciation of the value of the scientific territory that has been wrested from nature. In the following pages it may be of interest to give a personal impression of the main lines of attack and of the main results that have followed from them ; but of necessity on such a hurried survey much of interest and importance has to be omitted.

The discovery of X-rays naturally gave a great impetus to the study of the nature and origin of this remarkable radiation, but progress in this direction was at first slow, and as we shall see later, it is only in the last decade that great additions have been made to our knowledge. The immediate effect of the discovery of X-rays lay not so much in an investigation of the remarkable properties of this radiation as in the impetus it gave to research on the origin of the radiation and of the nature of the electric discharge in vacuum tubes—an investigation by Becquerel to test whether bodies which phosphoresced under visible light emitted a type of X-rays led immediately in 1896 to the discovery of a new property of matter, "radioactivity," the further study of which has had such momentous consequences. A close examination of the nature of the cathode rays led to the discovery of the "electron" in 1897, while the proof of the ionization of gases by X-rays and other agencies led to a much clearer knowledge of the mechanism of the transfer of electricity through gases.

In these great advances, the scientific men of this country and also of our Dominions beyond the seas have taken an honourable share, and in not a few directions a major share, and have done their best to uphold the great tradition of physics in this country.

PASSAGE OF ELECTRICITY THROUGH GASES.

At the time of the discovery of X-rays, little definite information was available as to the way in which electricity was transferred through a gas in the electric discharge, although the beautiful and varied phenomena that accompanied the discharge of electricity through gases at different pressures had long been known and carefully studied. The discovery of X-rays supplied the necessary key to a solution of this problem, for it was found that the passage of X-rays through gases imparted a temporary conductivity to the gas. The nature of this conductivity could be examined under very simple and ideal conditions in gases at ordinary pressure and

with weak electric fields. The transfer of electricity through gases was found to be completely explained by the movement in the electric field of positive and negative ions produced from the neutral gas by the action of the radiation. Much information was gained on the distinctive properties of positive and negative ions, the effects of which are so pronounced in the discharge through an ordinary vacuum tube. The discovery by Townsend of the conditions of the genesis of ions by collision gave a clear idea of the processes leading to the electric spark. At the same time, the ionization theory was found to account in a satisfactory way for the conductivity of flames and hot vapours, while the copious supply of electrons from a glowing body in high vacua was carefully studied by O. W. Richardson. It is a striking fact that these pure scientific researches in the conductivity of gases, which appeared at first sight to be of only academic interest, have resulted in most important practical applications. I may instance here the use of a hot filament as a rectifier and detector of electrical waves The supply of electrons from a glowing filament, coupled with the generations of ions by collision, has resulted in the invention of powerful electric oscillators and in the construction of amplifiers for magnifying minute currents, which have not only proved of great service in war, but have rendered possible radio-telephony across the Atlantic. Last, but not least, we have the invention of the Coolidge X-ray tube, which seems destined to play an important rôle in both radiology and in research.

It is also of interest to recall that the copious supply of electrons from a glowing filament has proved of great utility in studying the conditions of excitation of bright lines in the spectrum of gases and vapours

Another striking off-shoot of the study of ions has been the very direct and convincing proof of the atomic nature of electricity. Following the pioneer researches of J. S. Townsend, Sir J. J. Thomson and H. A. Wilson, Millikan has been able to show in a remarkably concrete way the existence of an atom of electricity and to determine its value with an accuracy, it is believed, of one in a thousand. We can now speak of an atom of electricity with the same certainty and conviction as we speak of the atom of matter, and it should be noted that the accurate evaluation of this unit of electric charge—probably the most fundamental constant in Nature—allows us at once to determine with equal precision the mass of all the atoms and the number of molecules in a cubic centimetre of gas at standard pressure and temperature.

DISCOVERY OF THE ELECTRON.

It seemed clear from the outset that the excitation of Röntgen rays in a discharge tube was closely connected with the cathode rays. While Sir William Crookes had long before suggested that these rays consisted of a stream of negatively-charged particles, scientific men were not as a rule agreed as to their nature and no definite information was available as to the mass or velocity of these flying particles. The discovery of the X-rays gave the necessary impetus to a further study of these cathode rays and then followed in 1897 the proof that they consisted of a stream of corpuscles or electrons of mass small compared with the lightest atom of matter and animated with enormous velocity dependent on the potential applied to the tube. By utilizing the swift electrons spontaneously emitted by radium, it was later shown by Kaufmann that the mass of the particle was entirely electrical in origin and that the electron consisted of a disembodied atom of negative electricity. It was soon found that electrons could be released from matter in a variety of ways, while the

correct interpretation of the Zeeman effect showed that the line spectrum of elements must be ascribed to the vibration of the electrons within the atom.

It is hardly necessary to emphasize the extraordinary importance of thie fundamental discovery in extending our knowledge of the constitution of matter and of the nature of electricity itself. The idea of the negative electron as a mobile or easily removed constituent of all atoms of matter which played a preponderating rôle in the structure of atoms and the reactions between them soon gained wide recognition, thanks largely to the researches and advocacy of Sir J. J. Thomson. The discovery of the electron has exercised a very deep influence on the whole trend of research in the subsequent period and on electrical theory, and has given a starting point for the attack on many apparently obscure electrical phenomena and on the great problem of the nature of radiation.

RADIO-ACTIVITY.

As we have seen, the discovery of the natural radiating power of uranium resulted from experiments to test whether bodies which phosphoresced under ordinary light emitted a type of penetrating X-rays. It was a dramatic and fortunate coincidence that Henri Becquerel should have had in his possession, amongst the great number of phosphorescent substances, a special salt of uranium and potassium and should have tried its effect on a photographic plate. We now know that the photographic action was not due to X-rays at all, but this observation of the natural radiating power of uranium disclosed a new and surprising property of matter and opened up the science of radio-activity which has had such an extraordinarily rapid development. Soon after followed the brilliant discovery and separation of radium by the Curies in which the radio-active property was so marked that it was difficult to explain and still more difficult to explain away. This was rapidly followed by the discovery of a number of new radio-active substances, both solid and gaseous, the activity of which died away with time. The apparent chaos of new facts and attempts at explanation were reduced to order by the transformation theory advanced by Rutherford and Soddy, in which radio-activity was explained as a consequence of the successive disintegration of the atoms. This theory gave the key to the unravelling of the remarkable series of transformations of the elements uranium, thorium, radium and actinium, and has led to the discovery of more than thirty new elements which have a limited life and are distinguished both by their radio-active and chemical properties. The radiations accompany these atomic explosions, and a closer examination has shown that some of these elements break up in several distinct ways. While the possibilities of multiple transformations are by no means exhausted, the position of nearly all these elements in the radio-active succession has been fixed and only a few outstanding questions, like the origin of actinium, still await a definite solution. In the early stages of the advance new radio-active substances were recognised by their typical radiations and by their characteristic rate of transformation. With the exception of radium and its emanation, most of the radio-active substances were obtained in almost infinitesimal quantity, but gradually methods were devised for studying the chemical properties of these new and evanescent elements. Steady progress was made notably by the work of Fleck and Von Hevesy, followed by a generalization of great importance advanced almost simultaneously, by Soddy, Russell and Fajans, in which the chemical properties of a sequence of elements were found to be closely connected with the nature of the radiation emitted.

The expulsion of one particle carrying two positive charges changed the position of the resulting element two places in the periodic grouping of the elements, while the expulsion of an electron carrying one unit of negative charge changed the position one group in the opposite direction. By this rule, the whole of the radio-active elements found their proper place in the periodic classification of the elements, and it was manifest that there was a close connection between the charge in an element and its position in the periodic table, thus affording for the first time a glimpse of the underlying reason of the periodic law. The power of this generalization was shown at once by the prediction, not only of a missing element in the uranium series, but of the nature of its radiation and its chemical properties. This was promptly verified by the discovery of Fajans and Göhring of the missing element.

The generalization given above can be stated in another way based on the conception of the nuclear atom where the nuclear charge is believed to be equal to the atomic number. The expulsion of an α particle of mass 4 lowers the nuclear charge by two units and its atomic weight by four, while the expulsion of the β particle carrying unit negative charge raises the atomic number by one unit, but does not appreciably change the atomic weight.

The examination of the chemical properties of the radio-active element led to another fundamental discovery. It had long been known that certain radio-active elements were inseparable by chemical methods, for example, mesothorium and radium, ionium and thorium. This led to the belief in the existence of "isotopes," as they have been termed, *i.e.*, elements of identical physical and chemical properties, but differing in atomic weights. In the nucleus theory of the atom, this means that isotopes have identical nuclear charges, but different in the constitution and mass of the nucleus. This bold idea, mainly due to Soddy, has received ample verification in the past few years. General results indicated that the end product of radium and also of thorium consisted of isotopes of ordinary lead but with different atomic weights. The existence of these types of lead of different atomic weight has been completely proved by the work of Soddy, T. Richards and Hoenigschmid. In addition to these two non-radio-active isotopes of ordinary lead, we have the best of reasons for believing that there are at least four isotopes of lead which show radio-active properties. All of these isotopes should show spectra identical with ordinary lead, but should differ from it only in density and atomic weight. In the case of one of these isotopes radium B, it has actually been shown that the characteristic α radiation spontaneously arising from it is identical with the α-ray spectrum of ordinary lead.

This new conception of isotopes must of necessity exercise profound influence on all work on atomic weights and lead to a close examination whether any of the ordinary elements are a mixture of isotopes. For example, Aston has recently given evidence that the rare gas neon, is not simple but a mixture of two isotopes.

The titanic violence of the explosion in a radio-active atom is shown by the expulsion of alpha particles at great speed and the ejection of electrons with nearly the velocity of light accompanied by intense X-rays of much greater penetrating power that can be excited in an X-ray tube.

Time does not allow me to speak of the great mass of important work that has been done in the nature and absorption of these radiations. I can only refer in passing to the proof that the alpha particle is a charged atom of helium and the deduction that helium is an important unit in the structure of the radio-active atoms.

The development of methods of counting the individual alpha particles has led to a convincing proof the reality of the chemical atom and has given us most important atomic and radio-active data. The remarkable achievement of C. T. R. Wilson in photographing the trail of ions in a gas due to the alpha and beta particles and the X-rays has shown in a striking way the main effects produced by these radiations in passing through matter and has afforded a visible proof—if proof were needed—of the individual identity of the alpha particle and electron.

A study of the deflection of a high speed alpha particle in passing through an atom of matter has brought out the enormous forces existing in the atom and has led to the conception of the " nucleus " atom, where the main mass of the atom is concentrated in a minute nucleus carrying a positive charge and surrounded at a distance by a distribution of negative electrons. This conception of the atom has proved very useful in explaining numerous important relations and has led to a first attempt to show the structure of the lighter atoms.

The close collision of high-speed alpha particles with the nuclei of light atoms. where the distance of approach is in some cases less than the diameter of an electron promises to throw much light on the nature of the forces between nuclei at exceedingly short distances.

ADVANCES IN X-RAYS.

Apart from the rapid development of our knowledge of the ionization of gases by X-rays and the pulse theory of the origin of X-rays, no outstanding results of importance on the problem of the nature of X-rays were obtained for an interval of more than ten years. Numerous studies were made of the scattering of X-rays by matter and the secondary radiations set up in absorbing material. Out of the complex mass of observational material, order was produced by a discovery by Barkla of fundamental importance. He found that each element emitted one or more types of radiation characteristic of that element when excited by X-rays of sufficient penetrating power. Coupled with other observations on secondary radiations, this fact strongly pointed to the conclusion that the X-rays must be a type of wave motion which could set up powerful vibrations in the atom under specific conditions, but the observations did not themselves throw any direct light of the actual wave lengths of the vibrations involved. The complete proof that X-rays were a type of light wave was supplied by Laue by showing that X-rays gave marked diffraction effects in passing through crystals. The full explanation of these results and the development of methods of determining the spectra of X-rays we owe to the work of W. H. and W. L. Bragg. It was shown by Bragg and Moseley and Darwin that the characteristic radiations of Barkla gave a bright line spectrum. The lines of advance then diverged into two directions. In the hands of the Braggs, the spectra of X-rays were developed with conspicuous success to determine the arrangement of atoms in numerous crystals and there seems to be no doubt that the powerful method will provide data of the utmost importance, not only in the arrangements of atoms in crystals, but in the actual structure of the atom.

Moseley, on the other hand, made a systematic examination of the X-ray spectra of elements with the special view of deciding whether these spectra were more intimately connected with the atomic number or the atomic weight of the element. He found that the characteristic radiation of the elements gave a similar type of spectra, the frequency of corresponding lines varying by definite intervals in passing from one element to the next. In this way he was able to show in the most conclusive

way that the spectra was connected with the atomic number of the element and not with the atomic weight. This atomic number is also believed to represent the number of positive units of charge in the nucleus of the atom, which varies by unity in passing from one atom to the next. These results showed that the atomic number or nuclear charge of an element is a more fundamental constant than its atomic weight for on the former depends all its ordinary physical and chemical properties. By study of the sequence of the spectra, he was able to state definitely the poss.ble number of elements and the atomic number and nature of the spectra to be expected of the missing elements. The results of Moseley's investigations are of outstanding importance and will undoubtedly mark one of the great stepping-stones of our knowledge of the relation and constitution of elements. We lament the loss of this brilliant investigator in the service of his country, but the law he discovered will serve as an imperishable memorial.

While Moseley's law undoubtedly fixes the number of possible elements defined by their atomic number, the discovery of isotopes show that there may exist elements of the same atomic number, but different atomic weights. As we have seen, in the case of lead, we already know of a number of such elements.

GENERAL CONSIDERATIONS.

The four main lines of advance we have discussed, while apparently independent, have in fact closely reacted on one another, and may be considered as four converging lines of attack in the three most fundamental problems of physics, *viz.*, the structure of the atom, the nature of electricity and the nature of radiation. In all these directions there has not only resulted a great addition to our scientific knowledge, but a wide change in our scientific ideas and outlook. This may be illustrated by consideration of the attitude of the scientific mind at the beginning and end of the period of advance under discussion. At the beginning of this period, while the majority of scientific men had a firm belief in the reality of atoms and molecules, there was an active school of thought who considered that the atomic hypothesis was in the nature of things unverifiable and that consequently atomic ideas should not be used as a basis of chemical theory. The ideas of the structure and relation of the atoms was exceedingly vague and indefinite and the periodic law of the elements was the one outstanding relation which appeared to show that all atoms had a similar constitution. There was, on the other hand, the firmest belief in the permanency and immutability of the atom and the atomic weight of an element was regarded as the one definite constant on which its properties depended. To-day no one doubts the truth of the atomic theory and we have convincing proof of the individual existence of atoms and of electrons as well, and know with considerable certainty the actual mass of the atoms and the number of atoms in any given weight of matter. We have strong evidence for believing that the atom is in the main a pure electrical structure and have made substantial progress in forming a general idea of the gross structure of atoms and of the relations between them. In place of the immutability of the atom, we have seen the process of the transformation of atoms going on before our eyes in the radio-active bodies and are lecturing to-night in an atmosphere filled with the flying fragments of atoms. The properties of an element are now believed to depend on a whole number representing the atomic number of the element and its nuclear charge, while the existence of isotopes has opened up new ideas of the interpretation of the atomic weight of the elements.

At the beginning of this period the scientific interest was concentrated mainly on the strains in the medium surrounding the conductor conveying an electric current; to-day our attention is more directed to the actual process of transfer of electricity in the wire itself and the nature of the electric carriers. The discovery of the electron has much widened our outlook in the nature of electricity and in the electron we recognise an actual disembodied atom of electricity.

Scientific opinion is much more undecided about the nature of positive electricity for no evidence has been obtained of the existence of a positive electron of small mass like the negative electron. So far the positive atom of electricity has never been found associated with a mass smaller than that of the hydrogen atom. There appears to be an essential difference between the positive and negative electron, possibly due to the much greater concentration of the electrical charge and consequently much greater mass of the former. Such a distinction or asymmetry between the two electrons seems to be essential to account for the structure of atoms.

While in the period under consideration, notable advances have been made in extending our knowledge of radiation, *e.g.*, by the proof that the line spectrum of elements is due to the vibration of electrons and the extension of the study of spectra into a new region of very short wave lengths, the whole problem of the nature and origin is still in a very unsettled state and beset by very great theoretical difficulties at almost every point. Time does not allow me to enter into details of the apparent contradictions in this, the great unsolved problem of modern physics, but I would like to draw attention to a remarkable attempt put forward by Bohr to explain the structure of the light atoms like hydrogen and helium and to account for their complex spectra. On the nucleus theory the hydrogen atom is believed to consist of a nucleus of one positive charge with one outlying electron. With this simple structure Bohr introduces the idea that the electron, when displaced from the nucleus, can occupy a number of stationary positions relative to the nucleus and that the frequency of the radiation emitted in passing from one state to another is governed by the quantum relation. While his theory does not profess at all to explain the nature of radiation, its remarkable success in several directions, notably in its deduction of the value of Balmer's constant, indicates that the equations are a formal representation of the results of the radiation process in the atom. During the last two years a generalized form of Bohr's theory, due to Summerfeld and others, has been remarkably successful in explaining, both qualitatively and quantitatively, the doubling of the lines in the hydrogen spectrum and the details of the stark effect where a single line in a strong electric field gives rise to a number of satellites.

The progress so far obtained is of good augury that we may in the near future be able to offer an explanation of some of the main points in the complicated spectra of elements and to make substantial advances in our knowledge of radiation and the detailed structure of the atom.

RECENT PROGRESS IN X-RAYS.

Since the outbreak of war, the call on the scientific services of the nation has, practically brought the full tide of scientific research in this country to a standstill but good progress continued to be made for some time in neutral countries and in the U.S.A.

The production on a commercial scale, early in the war, of that wonderful instrument the Coolidge X-ray tube—a triumph of the application of the latest

scientific knowledge and technique—has been a notable service not only to the radiologist but also to the workers in pure science, for it provided a powerful and controllable source of X-radiation generated at will over a wide range of voltage. It has proved an ideal source for the detailed study of X-ray spectra and especially for the study of the connection between the maximum frequency of the emitted radiation and the voltage applied to the tube. It had been for some years vaguely indicated that the maximum frequency v of the X-rays generated by the impact of an electron of energy E was given by the relation $E = hv$ where h is a fundamental constant called Planck's constant. An equation of this form had been shown to hold between the maximum energy of the electrons expelled from a metal by ultra-violet light of known frequency, but the experiments were complicated by contact differences of potential and the range of energy and wave length was small, corresponding only to that acquired by an electron falling through a few volts.

The Coolidge tube gave an opportunity for testing the correctness of the quantum relation over a wide range of voltage. The first experiments were made by Duane, using a steady source of potential of about 30,000 volts. The X-rays fell on a crystal surface and the minimum angle at which radiation was detected by the electric method gave the maximum frequency of the radiation. The results were in close accord with the quantum relation. By using a steady high potential current, the relation was found by Hull to hold to 100,000 volts and probably to 150,000 volts.

There seems to be no doubt of the essential correctness of the quantum relation and the experiments give a new experimental method of determination of the constant " h " which is in close agreement with the values obtained by other methods.

There is at present no physical explanation possible of this remarkable connection between energy and frequency, and it is doubtful whether it involves a new and unsuspected property of the electron itself or is connected in some way with the actual structure of the atom. There seems to be little reason to doubt that this relation will hold for still higher voltage than that mentioned for a heavy element like tungsten, but it would be a matter of great scientific interest to test its validity for an anticathode of very low atomic weight. There is no doubt that the actual amount of radiation will be much less for light atoms, but it is still a matter of conjecture whether hydrogen, for example, when bombarded by swift selections can give out all frequencies demanded by the quantum relation. It is of interest to note that the quantum relation holds for the general or continuous radiation emitted, but does not directly apply to the generation of the live spectrum emitted by the characteristic radiations. For example, Webster has shown that it is necessary to apply a slightly higher voltage than the theoretical to cause the " L " radiation of tungsten and the whole group of lines of different frequencies appear at once. It seems likely in these cases that the appearance of the line spectrum is a secondary consequence of the removal of a high speed electron.

Some beautiful photographs have been obtained of the X-ray spectra of tungsten showing clearly the lines of the K and L characteristic radiations. Another important advance has been made by De Broglie and Hull by showing that each element placed in the path of the rays shows several sharply marked absorption bands. These are connected with the excitation of characteristic radiations in the absorbing element and are the result of the rapid changes of absorption with frequency drawn attention to by Barkla many years ago.

In conclusion, I will say a few words about some occasional experiments made

with a Coolidge tube during the last few years. Before the work of Duane and Hull, some experiments were made by Barnes, Richardson and myself to examine the penetrating power of X-rays generated at different steady voltages. Aluminium and lead were used as absorbing material and the frequency of the radiation was extrapolated from rough data of variation of absorption with frequency over a limited range. The results indicated that the radiation appeared to reach a maximum penetrating power at about 120,000 volts and varied very little, if any, for a further increase up to 200,000 volts. These results seemed at first incompatible with the later results of Hull, who concluded that the frequency and therefore the penetrating power of the continuous radiation increased steadily with voltage. The cause of this apparent discrepancy was cleared up by further experiments in which much more powerful radiations were employed and where the absorption of the radiation was examined in some cases after passing through 1 cm. of lead, where the intensity of the radiation was reduced to less than one millionth of its initial value.

Special attention was paid to the absorption of the radiation by lead, and it was found that there was little change in the value μ of the coefficient of absorption of the end radiation between 79,000 and 144,000 volts, and no observable change between 105,000 and 144,000 volts. Over this range of voltage, the rays were nearly exponentially absorbed with a value of $\mu = 22$ (cm.)$^{-1}$. Above 144,000 volts, the absorption is no longer exponential, but the value of μ decreases progressively with increase of thickness of absorber. These apparently anomalous results can be readily explained when we take into account the marked absorption band due to lead which has been so clearly shown by De Broglie and Hull. This absorption band appears for a wave length 0·149 Å U. corresponding to 83,000 volts. Hull and Miss Rice have shown that there is a sudden increase in the absorption by lead for wave-lengths shorter than the critical value 0·149. By approximate extrapolation of the curves given by Hull and Miss Rice, it can be estimated that the radiation emitted by voltages between 83,000 and 125,000 volts should be more absorbed by lead than the radiation emitted just below 83,000 volts. Under such conditions, we should anticipate the value of μ for the end radiation to be sensibly constant over this interval. Actually we find μ nearly constant between 92,000 and 144,000 volts. Such a difference is to be anticipated from the nature of the experiments, for a radiation more penetrating than $\mu = 22$ must be present in some quantity in the great mass of general radiation before its presence can be detected by absorption methods. After this stage it is to be anticipated that the value of μ for the end radiation should progressively decrease with increase of voltage. The observations are in good accord with the results to be expected and the measurements are not of themselves inconsistent with the view that the quantum relation holds over the range of voltage examined.

The lowest value of μ observed was 8·5, corresponding to 196,000 volts. Even allowing that this is a maximum value, it is clear that the absorption in lead of the end radiation corresponding to 200,000 volts is very much greater than the value found for the penetrating γ rays from radium C, *viz.*, 0·5. We are able to draw some important conclusions from these results as to the probable wave length of the penetrating γ radiations from radium C. From the quantum relation, the shortest wave-length λ generated at 196,000 volts is ·063 Å.U. Since the absorption in lead of these waves is nearly twenty times greater than for the γ rays, it is clear that the penetrating gamma rays have a wave-length much shorter than ·06 Å.U. An

approximate estimate of the wave-length of the γ rays shows that they probably lie between ·02 and ·007 Å.U., corresponding to voltages of 600,000 and 2,000,000 volts. It is thus clear that we cannot hope for some time to produce in X-ray tubes such short waves as are spontaneously emitted by radium.

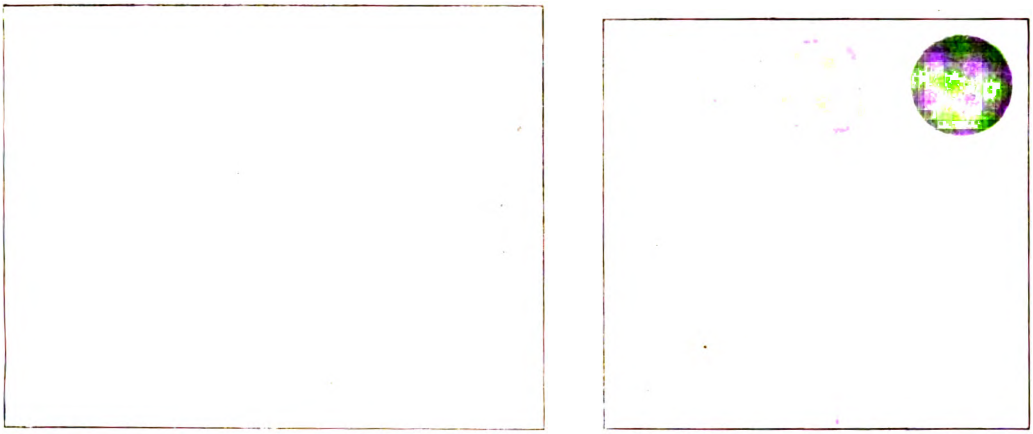
The two shortest wave-lengths detected by Rutherford and Andrade in the gamma ray spectrum from radium C. were ·072 and ·099 Å.U., corresponding to 174,000 and 125,000 volts. It is clear that there correspond to softer constituents of the main penetrating radiation. Later experiments by the crystal methods have failed to detect the presence of shorter waves in the γ rays. This may be due to the overlapping of the numerous lines that may be present or to the failure of the crystal to resolve such very short waves.

It seems probable, however, that where the crystal fails another powerful method may be used to push the study of spectra to still higher frequencies.

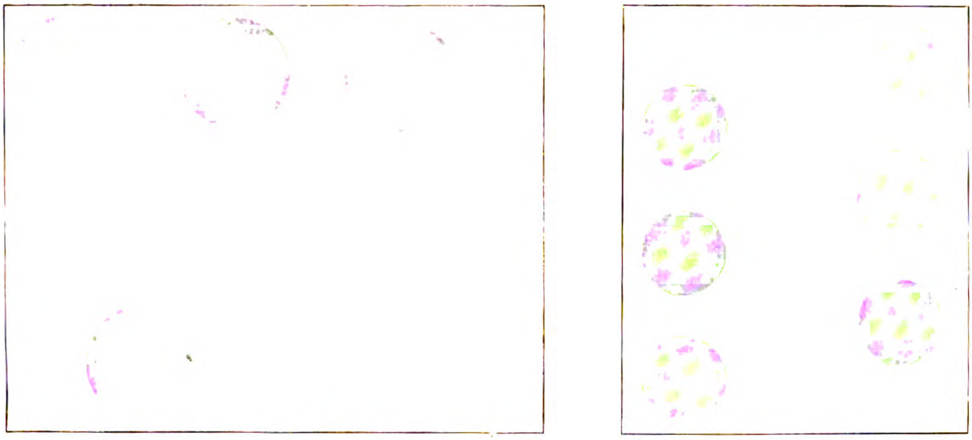
It is well known that when a pencil of β rays is beset by a magnetic field, a veritable spectrum is observed on the photographic plate, the continuous background due to β rays of all speeds is marked by definite and sharply-marked bands corresponding to groups of β rays of definite velocity. Such bands in the β ray spectrum are only observed for radio-active sources where strong γ rays accompany the β rays and it is reasonable to conclude that they are in some way connected with the emission of gamma rays. It seems proabble that some of the gamma rays in escaping from the structure of the atom are converted into β rays of corresponding energy and that consequently the energy E of the β particle is connected with the frequency of the radiation by the quantum relation $E = h\nu$. If this proves to be the case, the lines in the β ray spectrum supply a method of determining the frequency of the gamma rays from which they arise. A large number of these lines in the beta ray spectrum of radium C have been tabulated by Rutherford and Robinson. A well marked line, for example, was obtained for β rays of velocity 0·98, the velocity of light and of energy corresponding to a fall of potential of 2,102,000 volts. On the quantum relation this would correspond to a gamma ray of wave-length ·0059 Å.U. or less than $\frac{1}{100}$ of the wave-length given by soft X-rays.

If these conclusions can be verified, it is clear that the β ray spectrum should afford a reliable method of extending the investigation of X-ray spectra into the region of very short waves, whether the crystal method either breaks down or is practically ineffective.

It is clear from these results that there is little practical hope at present of obtaining X-ray tubes that can compete with radium or thorium in providing a source of X-rays of very short wave-length, for a potential of the order of two million volts would be necessary.



X-Ray Plate. Fig. 1. Radium Standard Plate.



Unfiltered "Soft" Rays. Fig. 3. Filtered Hard Rays.

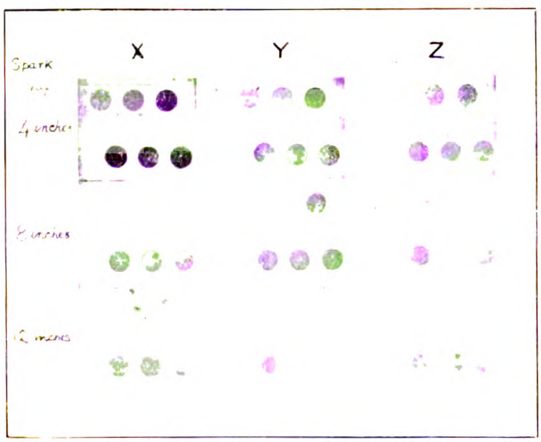


Fig. 5.

A BIOLOGICAL BASIS FOR PROTECTION AGAINST X-RAYS.

By C. R. C. LYSTER, M.R.C.S., and SIDNEY RUSS, D.Sc., Middlesex Hospital.

For a long time past we have had the question of the protection of those engaged in X-ray work much in mind. The harmful effects of these rays fall into two categories. The direct damage done to tissues by "soft," *i.e.*, easily absorbed rays, is mainly superficial; the indirect consequences may, however, be deep-seated. The harmful effects of "hard" *i.e.*, highly-penetrating X-rays, are incompletely known and are at the present day a subject of investigation; with their ever-extending use in X-ray therapy such investigation is of an urgent nature. Such penetrating radiation can and should be guarded against no less adequately than the more easily absorbed rays.

Up to the present no rational or standard basis of protection against the harmful effects of X-rays has been outlined or adopted. The degree of protection afforded by the apparatus of one manufacturer is very different from that of another; one may aim so as to reduce the intensity of the primary radiation in any other than the desired direction to 1 per cent. of its value, the other may aim for $\frac{1}{10}$th per cent. If, however, an operator is exposed to the radiation for ten times as long in the latter case as in the former he is no better protected. This serves to remind us that it is the quantity of radiation reaching the operator which determines his security or otherwise.

In the basis of protection we are submitting the amount of radiation reaching the operator in a given time is measured; a comparison is then made between this amount of radiation and an amount which is capable of giving rise to definite biological effects, such as, for instance, the production of erythema or blistering of the skin. Once such a comparison is made a definite statement as to the security of the operator, at any rate as regards the more easily absorbed types of X-rays, may be made.

DESCRIPTION OF THE METHOD ADOPTED.

The radiation reaching the operator has been measured by two methods, (1) electroscopically, (2) photographically. In view of the fact that it is desirable to make the method of measurement generally available we shall confine our attention here to the photographic method.

A quarter-plate is wrapped round with sheet lead 1·5 mms. thick, out of which four holes have been punched. The plate with the film outwards is carried in the pocket of the operator during a day's work—the stray X-rays of which he is the recipient will probably be sufficient to produce some impression upon the plate. This plate is now developed in the same dish and for the same time as a plate of the same make which has previously been exposed to a quantity of *standard* radiation, some multiple of which gives rise to a definite biological effect.

The standard radiation we use is either that emitted from an X-ray tube under definite working conditions or the beta and gamma rays from a known quantity of radium. An accurately timed exposure from either of such source results in what we may term a *biological basis* plate.

In the case of X-rays a plate is exposed to the rays from a Coolidge tube, which under certain conditions can be reproduced with accuracy for one and the same bulb. Should such conditions be fulfilled for another tube, however, the radiation is not necessarily the same, and it is for this reason that we prefer to use a radium standard. In our own case this consists of 7 milligrams of hydrated radium bromide ($Ra\ Br_2\ 2H_2O$) spread over a circle of 2 cms. diameter; the radium is covered over with a very thin layer of mica, the capsule having a screw-on lid which is fitted with an aluminium window ·1 mm. thick, through which are emitted beta and gamma rays.

If the capsule be placed flush upon the film side of a photographic plate an exposure of only a few seconds is required to give an appreciable effect, but the edges of the circles are very indistinct, which makes tint comparison difficult. Better definition is obtained by removing the capsule to a distance of 3 cms. and allowing the rays to reach the plate by means of a hole bored in a lead block on the top of which the radium capsule is placed.

The biological basis plates have records for six different times of exposure; in the case of X-rays 2, 4, 6, 8, 10, 12 seconds, in the case of radium ¼, ½, ¾, 1, 1½, 3 minutes. These give a convenient range of tints with which to compare the tint produced by the radiation reaching the plate carried by the operator.

The security of the operator is adjudged in the following manner:—Let us suppose that as a result of an average day's work the plate carried in the pocket of the operator gives a tint equal to the three minutes' exposure of the radium plate. Then we are able to say that if the more easily absorbed types of X-rays are in question he is the daily recipient of a quantity of radiation ten times which produces a recognisable biological change and fifty times which produces a blister.

THE PHOTOGRAPHIC EFFECT OF "HARD" AND "SOFT" X-RAYS.

The remark that "soft" X-rays are more active photographically than "hard" X-rays is often heard. Certain it is that radiographic contrast is enhanced by the use of "soft" rather than of "hard" X-rays; but whether, if a photographic film be made to absorb identical amounts of "soft" and "hard" X-rays, different depths of tint will result in the two cases is a matter for experiment to decide. This is in fact a very important consideration in estimating to what extent our method of measuring safety is a rational and valid one. The wider the range of X radiation that the method covers the greater its value.

The point under investigation is whether there will be equality of photographic tint when the ionization values are equal. This question has been answered in the negative by Barkla and Martyn for the "characteristic" radiation of a number of elements. Such radiation is, however, in the main of much longer wave-length than the X-rays under consideration here.

A large number of observations have been made by exposing photographic plates to the radiation from the Coolidge tube ranging from 2 to 12 inches alternative spark-gap, in each case arranging that the photographic film is acted upon by beams of X-rays which produce identical ionization in the air of a small electroscope $8 \times 8 \times 8$ cms., such radiation being "soft" or "hard" or a mixture of both in various proportions. This adjustment was made as follows:—A beam of X-rays after passing through a diaphragm was allowed to enter through an aluminium window cut in the lead wall of a gold leaf electroscope.

The ionization produced in the electroscope by the X-rays was measured by

the time taken for the gold leaf to move over a certain number of divisions in the scale of the eye-piece of a tele-microscope. A photographic plate was then mounted flush with the wall of the electroscope. The plate was placed in a slot and covered with sheet lead, in which six holes were punched, these holes allowed access of the rays to the film of the plate, they could all, however, be covered over with lead shutters so that exposure through any particular aperture could be made when desired. When taking such photographs the particular aperture was mounted immediately in front of the aluminium window through which the X-rays gained access to the electroscope. In this way it was assured that the photographic plate was being acted upon by radiation, the ionizing value of which had just previously been determined.

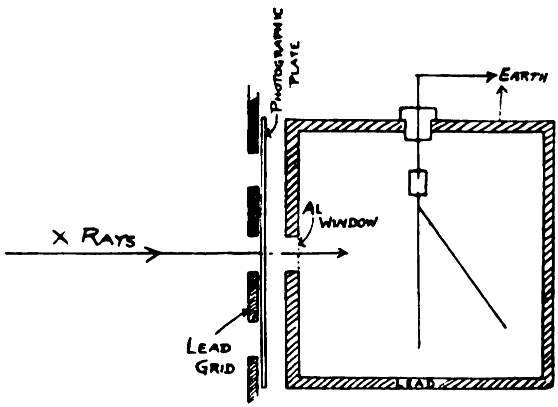


Fig. 2.

When a Coolidge tube is working under specified conditions of alternative spark-gap and heating current in the spiral the result of changing either of these variables is to alter the output and character of the X-rays, the former is at once detected by a change in the rate of fall of the gold leaf of the electroscope, the latter by absorption measurements. It is, however, a comparatively easy matter to adjust either the heating current or the resistance in the primary of the induction coil so that the ionization recorded in the electroscope is identical over a wide range of alternative spark-gaps, *i.e.*, in going from a region of " soft " X-rays to the region of highly penetrating rays.

A series on these lines was taken ranging from 2 to 12 inches spark-gap. From the data in Table I. it will be seen that as the spark-gap is increased the heating current through the spiral has to be reduced in order that the radiation from the bulb shall have the same ionizing power in the distant electroscope.

TABLE I.

Alternative spark-gap.	Heating Current in spiral.
2 inches	4·88 ampères.
4 ,,	4·35 ,,
6 ,,	4·18 ,,
8 ,,	4·10 ,,
10 ,,	4·06 ,,
12 ,,	4·05 ,,

The six plates after exposure were developed in the same dish for the same length of time. Roughly speaking, there was no great difference between the tint

on one plate and that corresponding to the same length of exposure on any other, but those taken with soft X-rays were generally a little darker than those with hard X-rays an upper limit for the ratio of tints being two.

In order to test this matter still more stringently, a comparison was made between the unscreened rays from a "soft" tube, *e.g.*, 4 inches alternative spark-gap and the rays from a very "hard" tube, *e.g.*, 12 inches alternative spark-gap, the rays in the latter case, being screened through 12·5 mm. of aluminium before acting upon the photographic plate; adjustment to equality of ionizing power of the two beams was made as described.

The two plates were developed under the same conditions and are reproduced in Fig. 3.

It will be seen that the "soft" X-rays have had more action upon the plate. than those of much shorter wave-length; examination of the plate shows that about 2·5 times the exposure must be made with the "hard" rays in order to obtain the same depth of tint as is obtained with the "soft" rays. This factor is not so large as to exclude the photographic method being employed for the measurements of X-rays in general; for the particular matter under consideration this limit of the factor is rarely, if ever, reached, for it is generally recognised that the greatest need for protection from X-rays is during screen examinations and under these conditions the most penetrating type of X-rays is rarely used. Hence if we take the plate which has been carried by the operator in a radiographic department for the purpose of the test and develop it under the same conditions as the biological basis plate, a direct comparison of tints may be used and deductions drawn therefrom without applying any numerical factor, unless very penetrating radiation is in question.

The fact appears, then, that the secondary rays excited in the silver of a photographic plate by the primary beam of X-rays do not play a dominant part in determining the depth of tint thereon, over a considerable range of the X-ray spectrum. This is probably due in the first place to the fact that radiographic use is made of rays of considerably shorter wave-length than that of the K series of silver, and secondly, to the comparatively small fraction of the energy of the primary beam that is converted into "characteristic" radiation. There is also the probability, which has kindly been pointed out to us by Professor Barkla, that the electroscope favours the penetrating radiation by virtue of the excitation in the air of the electroscope of J and I characteristic radiation.

Absorption measurements made upon the radiation from a Coolidge tube at an alternative spark-gap of 4 inches provide data of Table 2.

TABLE II.

Screen.	Intensity of ionization.
0	100 units.
·6 mm. aluminium	58·4
1·2	47·9
2·4	38·8
4·8	20·9

The first millimetre of aluminium absorbs the radiation to an extent represented by $\lambda = 6{\cdot}14$ cm.$^{-1}$ obtained according to the usual expression

$$\lambda = \frac{2{\cdot}301 \times \text{diff. in logs of ionization values}}{\text{thickness of screen.}}$$

As the beam is more and more filtered λ diminishes; for a Coolidge tube at about

10 inches spark-gap the rays being first filtered through 12 mms. of aluminium the value of λ has fallen to about ·62 cm.$^{-1}$ For rays of intermediate penetrating power a corresponding value of λ is found.

Owen has shown that a simple relation holds between the coefficient of absorption in aluminium of a beam of X-rays and the wave-length of the radiation.

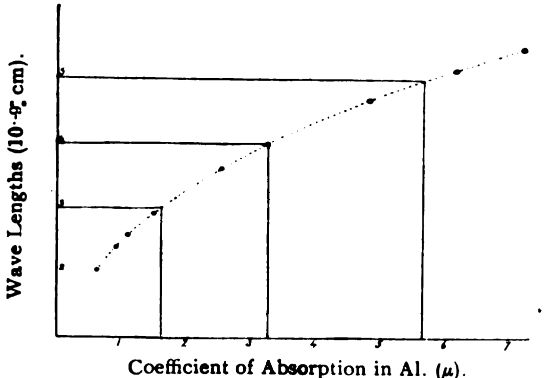


Fig. 4.

For the range of spark-gaps 2-12 inches the radiation comprises all types from "very soft" to "very hard." When absorption measurements are carried out a range of coefficients *vide* Column 2, Table 3, is found; the wave-lengths in Column 3 are calculated therefrom and illustrated in Fig. 4.

TABLE III.

Type of radiation.	Value of Coefficient of absorption in aluminium.	Wave-length.
Very soft	7·20	$5{\cdot}5 \times 10^{-9}$ cm.
—	6·14	5·16
Soft	4·8	4·68
—	3·2	4·00
Medium	2·53	3·62
—	1·48	2·92
Hard	1·09	2·59
—	·90	2·40
Very hard	·67	2·13
—	·62	2·06

The K characteristic radiation of silver has a value of $\lambda = 6{\cdot}9$ cm.$^{-1}$ In view of the fact that such "characteristic" radiation is mainly excited by rays of just a little shorter wave-length than its own it seems clear that under the radiographic conditions in question it is not such as to augment to a great extent what may be termed the direct photographic action of the primary beam of X-rays.

THE RELATIVE SENSITIVENESS OF VARIOUS X-RAY PLATES.

There is an appreciable difference in speed of the various makes of X-ray plates. In order to see to what extent notice should be taken of this in the above procedur- tests were carried out upon three different varieties of plates; they were by proe minent makers and will be designated as X, Y and Z.

For the purpose of the test, "soft", "medium" and "hard" X-rays were used corresponding to alternative spark-gaps of 4, 8 and 12 inches respectively.

In each case before allowing the plates to be acted upon by the rays, adjustment was made in the electroscope so that equality of ionizing power of the beam was obtained, irrespective of the quality.

The nine plates, subsequent to exposure (for times ½, 1, 1½, 2, 2½, 3 minutes) were all developed simultaneously. They are reproduced in Fig. 5.

Inspection shows that plate X is to an appreciable degree more sensitive than Y and Y than Z, the ratio of speeds being approximately 2 : 1½ : 1. This ratio depends slightly upon whether comparison is made with "hard" or "soft" rays.

The practical issue of this test is that the same make of plate should be used for the *biological basis* plate as is used by the operator when he exposes the test plate to the radiation which he may be receiving. If different plates are used, note should be made of it and their relative speeds taken into account in the final deductions.

RESULTS OBTAINED BY THE METHOD DESCRIBED.

Safety from X-rays is a two-fold problem. One is a matter entirely of protective devices in the design of the installation; the other consists in precautions taken by the X-ray operator himself.

At the present time in determining the safety or otherwise of an installation both factors come into consideration.

In order to make some comparative observations we have asked operators in various X-ray departments to carry a test plate about with them during the work of a whole day.

The plates were then collected and developed with a *biological basis* plate, with the following results.

Test number.	Equivalent exposure on *biological basis* plate.
1	No photographic action.
2	No photographic action.
3	Less than ¼ minute.
4	Less than ¼ minute.
3	20 seconds.
6	40 seconds.
7	45 seconds.
8	45 seconds.
9	1 minute.
10	1½ minutes.
11	3 minutes.
12	More than 3 minutes.

It will be seen that a considerable range of safety has been met in these preliminary tests.

We are anxious to see the method given a more extensive trial and for this purpose we invite the co-operation of medical officers with whom it is a matter of concern that adequate protection is assured to all those who are engaged in the work of their X-ray departments.

The procedure we propose is simple and as follows:—

1. Two quarter-plates, such as are ordinarily used in the department, are taken. One is kept as a control, the other is covered on the film side with sheet lead, except for four circular holes, 1·5 cm. diameter, punched out of the lead.

2. The lead-covered plate is carried by the X-ray operator during the whole of one day's work, care being taken that the film faces outwards from the person carrying it.
3. Both plates are sent to the Middlesex Hospital, together with a statement as to how many days per week are spent at the work by the particular operator in question.
4. A report as to the safety or otherwise of the installation as regards the particular individual in question and under the conditions specified (with the proviso concerning very penetrating rays as stated in the opening paragraphs of this paper) will then be issued as soon as possible.

This proposal on our part arises from our conviction that adequate steps are not always taken, even at the present time, for protection against the dangers of X-rays.

It appears to us a matter of national importance that medical X-ray procedure should not come under the category of dangerous occupations.

MOBILE X-RAY WAGGON UNIT.

By *HOWARD C. HEAD.*

Among the many special productions called for by the requirements of the armies in the field, and at home, none can be more interesting than the Mobile X-ray Unit. Its design opens up great possibilities for the inventive genius of the automobile engineer, the electrical engineer and the radiologist, but to take advantage of all the suggestions and to incorporate those of value in the construction of a practical plant whilst omitting, without offence, the impractical, I say it with all modesty, requires the exercise of a good deal of ingenuity.

There are many initial difficulties to overcome before one can proceed to carry out the preconceived ideas of the completed unit. The automobile engineer has very strong views on departing from the standard chassis, and it is with great difficulty that he can be persuaded to alter or make any modification of design to arrange, for example, for the direct drive of the generator by the engine of the car.

The power electrical engineer does not appreciate the fact that the generator must be of special design to deal with oscillatory high-tension load, and as you will well understand it is also not easy to incorporate all the requirements of the up-to-date radiologist. So one starts off by coming down to earth and taking things as one finds them, and building one's equipment out of the materials to hand.

Therefore, in describing this mobile X-ray unit to you this evening, I do not present it as my conception of the perfect X-ray Waggon, but as a unit which is a development of previous attempts, and at the same time I may be able to indicate some original improvements which can be elaborated in future outfits, and this, considering the difficulties from a manufacturing point of view at the present time, is all one can hope to accomplish.

The value of these motor X-ray units has been much criticized, but there is no doubt that they are of great practical utility and may remain of special value after the war. By their means it has become possible to have the X-ray apparatus and its power unit taken to its work instead of the work having to be brought to some centre where there is an established plant, and this without any loss of power

or output. At the same time there may be a considerable saving to the patient, and further, the question of distance and the difficulties and risks to be negotiated are frequently such as to make the undertaking impracticable.

In the alleviation of suffering the chief consideration without doubt is promptness in the application of the necessary treatment. With the phenomenal increase in the variety of death-dealing instruments which characterize modern warfare, there has been a corresponding increase in the numbers of wounded, and as a consequence the evacuation has had to be speeded up to an extent hitherto thought impossible.

The employment of such a unit has helped considerably to that most desired end.

It is of interest to mention that some years prior to the war the Central Powers had attached to each of their Army Divisions a horse-drawn X-ray unit, but these were comparatively of an inconvenient and cumbersome type, as you will see from the slides I will now show.

I cannot say what their present-day developments are, if any, but as an engineer in these days of motor vehicles it is most incongruous to consider a horse-drawn waggon for this purpose.

The first serious point for consideration was the selection of the type of chassis most suitable and convenient for the work, but this, in spite of the great variety of most excellent makes, was not so difficult, because the model of the Austin Motor Company offered in addition to its general excellence the special feature that the loading line was much lower and nearer the ground than any other type employed, being practically equal to an underslung type of car. This is most important for the following reasons:—

1. The induction coil and its fittings, the distribution switchboard and the control board can be all manipulated from the car, because the controls come within the reach of man of average height, so that none of these pieces of apparatus require moving into the portable X-ray theatre.
2. As the body of the car is so near the ground, only one step is necessary instead of four or five as with an ordinary chassis, and this is a great advantage in loading and unloading the plant or, if necessity should arise, getting patients in and out of the vehicle.
3. It enables all the weight to be kept low and there is less tendency for such a car to overturn even when at a considerable angle, and owing to its low centre of gravity it is practically immune from side-slip.

It is unnecessary for me to give a detailed description of the chassis, as this is best obtained from the maker's catalogue, but one or two points are of interest. The model is a 2-3 ton chassis, and fitted with an engine with four separate cylinders, but that which is of special importance to us in the present case is the differential box, the rear axle and the frame.

The drive is distributed through substantial bevel wheels by a propeller shaft to each rear wheel. This special arrangement enables a light back axle to be provided without any massive parts in the centre; consequently such an axle will run on rough roads without the wheels losing contact with the ground, as the springs are not subject to reaction through the inertia of heavy central axle parts. The bevel wheel of the drive is mounted upon a short sleeve which carries the rear wheel itself, and the two drives are connected by an axle giving all the advantages of a dead axle combined with a live bevel drive. It is owing to this construction that a

specially designed frame built on the lattice girder principle can be utilized to obtain the low loading line or low body which is such a valuable advantage for this particular work. The change speed is operated through a gate and is carried direct on the top of the gear box cover with the control handle to the left of the driver. This enables speeds to be changed with facility even on the roughest roads.

One of the first equipments produced with this type of chassis was built in July, 1915, and has since been in use near Paris, and many of its shortcomings have been eliminated. The present outfit is fitted with a panelled teak body, not only elegant in appearance, but very practical for use in such climates as Mesopotamia, where this car is destined for. The size of the body is 12 ft. 9 in. long, 7 ft. wide and 7 ft. high, and this is divided into two compartments—(1) the photographic dark-room and (2) the room containing the X-ray apparatus. The photographic dark-room measures 3 ft. 4 in. long by 7 ft. wide, and is practically a tabloid studio, but fitted with every arrangement to facilitate the work. It is partially lead-lined, that is on the side towards the portable X-ray theatre, to protect the plates, etc., from the radiation of the tube. Water is obtained from a 30-gallon storage tank underneath, and this is pumped as required by a hand pump into a second smaller tank fitted above the sink on one side. The sink is fitted with a removable cover arranged to form a rocking table. Immediately under this a light-tight drawer is provided, in which a partially developed or unfixed plate may be temporarily housed in the event of the operator having to open the door for any purpose. A special safe-light is provided above the sink with easily adjusted control for either daylight or electric light. On the opposite side of the room are several bins for chemicals and plates, and the tops of these form a printing and plate-changing bench, also provided with a duplicated safe-light. Draining racks, nets for measuring glasses and other necessary apparatus and racks for bottles are fitted round the walls. A folding seat is provided for the operator, and last, but not least, an electrically-driven fan fitted to a special flue is provided to draw off tainted air from the room, fresh air being drawn in through special vents near the floor.

The apparatus room is 9 ft. long by 7 ft. wide, and the apparatus is so arranged in this room that radiography of the extremities can be carried out with a tube stand, and it is even possible should the emergency occur to erect the couch and radiograph the patient on the same, but I must admit that this latter is not working under ideal conditions. Every piece of apparatus has a special fitting to which it is secured by clamps, and turn buttons, but for additional safety a leather strap and metal buckle is fastened round each article, so that, however rough the travelling may be, the apparatus cannot suffer.

In addition there is the portable X-ray theatre. This measures 12 ft. 9 in. long by 10 ft. 6 in. deep by 9 ft. high at back, and 6 ft. 8 in. high at front. A framework of poles and tie-rods is erected on the near side when the caravan is on the road, and these, together with the cover, are stored upon the roof. Having the poles erected, the tent canvas roof and sides are placed in position. The portion forming the roof and front is rolled down over the poles after the ends which are provided with openings have been attached to the frame. The canvas covering is of special material, 3-ply, and so thick and close in texture that light and water are absolutely excluded. In addition a second light water-proofed canvas covering is provided for tropical climates. The theatre is lit by an electric lamp which may be connected, if desired, to the foot switch. The material used for forming the cover of this tent is so efficient

that X-ray work can be carried on inside even when there is brilliant sunshine outside.

I will now draw your attention to the electrical equipment. The generator, which you will observe is situated on the exhaust side of the engine, is of special construction and is driven by means of a Westinghouse Morse Rocker Chain coupled to the main shaft of the engine and is designed to give an output of 3 kilowatt or 20 amp. at 150 volts when the engine is running at 1,700 r.p.m. The rocker chain is disconnected when the car is running on the road and is only connected when the generator is to be used either for charging the battery of accumulators or running the X-ray plant direct. When the engine is driving the generator the whole of the starting, running and stopping can be carried out from the position of the main distribution board at the rear of the car. The generator is of light design having a laminated field. It is provided with special protection against dust and dirt and in addition has a fan on the shaft of the armature for cooling purposes. The windings are also protected by a condenser and lamp in parallel to one another to prevent high-frequency surgings getting back to the machine.

A special battery of accumulators is fitted in two special cupboards at the back of the driver's cab, and the doors of these cupboards are fitted with louvres to ensure perfect ventilation ; by this arrangement no acid fumes can enter the car and the whole battery is most accessible should it be necessary to give it attention. The battery is built up in special ebonite composition boxes, these being superior to celluloid, because the latter material decomposes under the influence of heat ; further, as the boxes chosen are unbreakable under ordinary conditions of handling, they are preferable to ebonite, and lead-lined wood cases are prohibited on account of weight. Each cell is fitted with a float to indicate the level of the electrolyte. The accumulator battery consists of thirty-eight two-compartment 4-volt units, making seventy-six cells in all of the sealed-in type. The capacity of each cell is 80 ampère hours (intermittent) or 10 ampères for 2½ hours, or 30 ampères for five minutes.

Therefore, the X-ray operator is provided with a supply of energy capable of undertaking the quickest work and the most difficult cases, for he has at his command 20 amps. at 150 volts from his generator, 30 ampères at 150 volts for five minutes from his battery of accumulators, or 50 ampères at 150 volts when running with generator and accumulators in parallel.

Now so far as the X-ray outfit itself is concerned, this I consider may be open to a certain amount of criticism, not that it is inefficient in any way, but individual tastes vary in the selection of apparatus, and as this outfit is for use at the front it has been thought expedient to adopt in several instances, such as the couch, stereoscope, etc., the standard War Office equipment for field service, so that in case of necessity spares or renewals could be obtained locally.

Apart from this, the outfit is provided with a 16-in. spark intense discharge induction coil built up in box form and fitted with a variable primary winding. The coil is mounted on a table on pneumatic buffers to provide against mechanical shock, and beneath the table are fitted three interrupters, a dipper mercury interrupter, a centrifugal mercury interrupter and an electrolytic interrupter, together with the condenser, speed regulators and a small interrupter selector switchboard.

In order that the coil may be operated without moving it into the portable X-ray theatre, a portion of the side of the car is made to hinge upwards and a distribution shelf for the valve tubes, milliammeter, spark gap and rheophors is attached and connection is established to the X-ray couch. Next to the coil is the Coolidge

control outfit fitted with a 12-volt accumulator of very large capacity. A further use has been made of this battery and that is for supplying the necessary current for the head, side and tail lamps of the car through a switchboard mounted on the dash. To change over from the lamps to the Coolidge connection, or to put the battery in series with the main one for charging, is the work of a moment.

On the same side of the car at the end is the switchgear, this consists of a main distribution switchboard and a control switchboard for the primary circuit of the coil. The latter is provided with a transport case. The former is mounted on an iron pillar on which it rotates so that it can be manipulated either from inside the car or from the portable theatre. In the latter case a door at the side of the car is opened, when both switchboards can face into the portable theatre with the Coolidge control to the left hand. So that up to the present all the apparatus remains and is used in the car. The only portions of the equipment that it is necessary to bring into the portable theatre are the couch, foot switch and, of course, the tube screen, etc., but none of the heavy gear. On the opposite side of the room containing the apparatus is fitted the portable field service couch, a tube stand and all the other necessary adjuncts for carrying out the best work, including localizers by screen and plate, protection aprons, gloves, face masks, etc., plate-holders, fluorescent and intensifying screens, plate recorders, in fact it is extraordinary how much one can pack away in a small space.

At the end of the apparatus room are tube boxes in racks for the equipment, which includes, in addition to the Coolidge tube, six tungsten target tubes and three valve tubes. On the inside of the roof is fitted the stereoscope, which can be used inverted in this position, and in addition a small portable viewing box is provided.

As one of the functions of this type of plant is to provide a powerful apparatus for use in any temporary hospital, or house, a means must be found for accomplishing this with the least amount of trouble. The plant has, therefore, been so arranged that the minimum number of pieces of apparatus are carried into the building which is serving as the temporary hospital. It is only necessary to take the induction coil and its fittings, together with a trestle table which is carried on the door of the car, the couch and the small control switchboard, all the other apparatus including the interrupters remain in the car and connection is established from the car to the temporary X-ray room in the hospital by special cable, which is wound on cable drums fitted by the chauffeur's cab. One can, therefore, carry on radiography and radioscopy, and for that matter therapeutic treatment as well, in the car itself, in the portable X-ray theatre, or in any hospital, house or temporary building.

I should now like to mention how the plant is operated from the main distribution board. The engine may be started by using the battery of accumulators for motoring the generator in the same way as a self-starter on a motor car, and this is carried out by closing the D.P. switch on the left-hand side and the S.P. switch at the bottom, and slowly switching on the starter or automatic cut-out. The speed of the engine is controlled by a Bowden wire throttle control mounted beside the main switchboard, and below near the floor is an " on " and " off " switch for earthing the primary of the magneto and thereby stopping the engine, so that there is no necessity to leave the portable X-ray theatre, or in fact the vicinity of the switchboard to start up the plant, to operate it or to shut it down. The row of fuses on the top of the board control the interior and tent lights and ventilating fans, as well as the motors of the mechanical interrupters, and these are all supplied with

energy by the accumulators. In the case of the interrupters this is very important in order that the speed may remain constant.

To charge the main accumulator battery after ascertaining by means of the voltmeter switch that the voltage for charging is the correct one, close the S.P. switch at the bottom, the D.P. switch on the left-hand side and the automatic cut-out. Beneath the automatic cut-out is a shunt regulator for regulating the output of the generator.

A regulator is provided for controlling the lights of the interior of the car, situated underneath the row of fuses.

When it is desired to operate the apparatus from the accumulators entirely the left-hand D.P. switch is closed, and the Niphan socket on the left is connected to its plug, which is attached to the cable hanging behind the switchboard, but if the coil circuit is to be operated from the generator then both D.P. switches are closed and the Niphan socket on the right-hand side is used. Again, should it be desirable to parallel the generator and accumulator battery then all switches must be closed, and the automatic cut-out as well.

When paralleling generator and battery care must be taken to keep the voltages equal under all conditions of load.

It will be now obvious that with this switchboard and plant one can obtain current in the following ways :—

(1) Running the X-ray apparatus direct from the generator.

(2) Running the X-ray apparatus direct from the accumulator battery.

(3) Running the X-ray apparatus direct with the generator and accumulators in parallel.

(4) Running the X-ray apparatus direct from the generator and at the same time charging the accumulator battery.

(5) Running the generator for charging the accumulator battery only.

I have already mentioned that the Coolidge tube battery can be charged with the main battery, and there is provided at the side of the switchboard a small switch for cutting in or out these extra cells.

The connecting up of the various parts of the apparatus is next proceeded with, and this is carried out by means of the special cables provided. The induction coil and the foot switch are each connected by their respective plugs to the sockets on the control board, and the foot switch and main switch on the control board are in parallel so that either can be used irrespective of the other. The other socket on the control board is connected by means of a Niphan plug to the small distribution board for the interruptors.

There is in addition a regulating resistance in series with the primary of the induction coil and an ampèremeter. As has been previously mentioned, the induction coil is provided with a variable self-induction and this can be altered by means of a plug contact in order to obtain the most suitable self-induction for the interrupter selected.

The small switchboard for the interrupters is provided so that the operator can change from one to another by simply changing over two switches, one controlling the motor circuits, and the other the coil circuits. All the plug connections are made non-reversible, with the exception of one on the control board, and this is left reversible in order that the polarity of the primary and secondary circuits can be changed instantly if occasion requires.

This completes the primary connections and the secondary or tube circuit is assembled by placing the high-tension distributing bracket in front of the coil and connecting up the coil to the milliammeter, valve tube and spark gap, care being taken that the pole of the coil adjacent to the switchboards is negative. This is somewhat important, as the Coolidge tube control is on this side.

The couch is erected in the portable theatre, a tube inserted in the tube box and connected to the distributing bracket by the spring rheophors. If desirable, the three-ply wooden top of the couch can be removed and an ordinary stretcher used in its place.

Everything is now ready to commence work. The engine and generator are running and the accumulator battery is charged. It is now only necessary to close the correct switches for motor and coil circuits and the tube will then be excited by closing either the foot switch or the control switch. It will be noticed in working that as soon as the load of the induction coil comes on the voltage of the generator will fall, therefore when regulating the coil rheostat, the shunt regulator should also be adjusted to maintain a constant voltage. In this outfit one great inconvenience is obviated and that is the speed of the mercury interrupters is kept constant by always running them from the main battery and not from the generator.

When using the Coolidge tube instead of an ordinary tube the only alterations that have to be made are in the secondary circuit, and such connections are well known to all workers. These connections, as well as the Coolidge control, have been specially designed to fit in with the other modifications necessary in an outfit of this description.

I think you will agree that such a mobile X-ray unit affords exactly similar facilities to those available in the base hospitals, and when one considers the many temporary hospitals established in large private hotels and houses at home here and on all the fronts without X-ray outfits of their own its usefulness is at once recognised.

Many wonderful advances have been made on the surgical and medical side in the treatment of the wounded, but these have been more than equalled by the provision of such a vehicle and equipment, and furfher it proves that the ways and means are available in this country to meet any possible requirements of the Army Medical Corps or allied branches.

The possibilities of the utility of such a unit in normal times for mining districts, scattered areas and so forth are by no means small, but sufficient is the task which confronts us now, and we can return to the other uses at a more opportune time.

NEW MEMBERS ELECTED BY BALLOT.

Name.	*Proposer.*	*Seconder.*	*Date of Election.*
H. CLYDE SNOOK, Electrical Engineer, Victor Electric Corporation, Jackson Boulevard and Robey Street, Chiacgo	Geoffrey Pearce ..	Robert Knox ..	5th Mar., 1918
MRS. CONSTANCE EMILY O'NEAL, Assistant Radiographer, Prince of Wales Hospital, Marylebone, Manor Hotel, 32, Westbourne Terrace, W.	G. H. Rodman ..	Robert Knox ..	5th Mar., 1918

NEW MEMBERS ELECTED BY BALLOT—*Continued.*

Name.	*Proposer.*	*Seconder.*	*Date of Election.*
EMILY HELEN CROSSLEY, Nursing Sister, C.A.M.C. (Radiographer), Taplow Lodge, Taplow, Bucks. ..	J. D. Morgan ..	Robert Knox ..	**5th Mar., 1918**
FREDERICK JAMES ALEXANDER MAYES, M.R.C.S., L.R.C.P., Radiologist, 34, Gloucester Road, Bishopston, Bristol	Robert Knox ..	Geoffrey Pearce ..	**5th Mar., 1918**
GRAHAM HUNT, Dentist, 6, Park Crescent, Torquay	R. S. Wright ..	E. E. Burnside ..	**5th Mar., 1918**
CAPT. FRANCIS SWANSTON HAWK, L.I.A., R.A.M.C., Connaught Hospital, Aldershot	Robert Knox ..	C. E. S. Phillips	**9th April, 1918**
CAPT. JOHN MUIR, B.Sc., M.B., Ch.B., Penwarne, Rodten, Herts. ..	C. E. S. Phillips ..	Robert Knox ..	**9th April, 1918**
NORMAN E. ALDRIDGE, M.B., C.M. (Edin.), Hon. Medical Officer in Charge, X-ray and Electrical Depts., Royal South Hants. Hospital, 7, Cumberland Place, Southampton	Robert Knox ..	Geoffrey Pearce ..	**9th April, 1918**
JOHN KEIR MUIR, M.R.C.S., Capt., R.A.M.C., Radiographer, 62 General Hospital, Italy	H. E. Gamlen ..	Robert Knox ..	**9th April, 1918**
A. H. ROLPH, C.A.M.C., Radiologist, No. 4 Canadian General Hospital, Basingstoke	A. Howard Pirie ..	G. H. Rodman ..	**9th April, 1918**
ALFRED HERBERT WARSH, General Medical Practitioner, Hollycroft, Chipstead Road, Banstead, Surrey	Robert Knox ..	G. H. Rodman ..	**9th April, 1918**
PERCY LAKE HOPE, M.R.C.S., L.R.C.P., CAPT., R.A.M.C., Westdean, Queen's Road, Worthing ..	Geoffrey Pearce ..	Robert Knox ..	**9th April, 1918**
HECTOR PILON, Electrical Engineer, 53, Rue de Paris, Asnières, Seine	G. W. C. Kaye ..	W. F. Higgins ..	**9th April, 1918**
F. W. ASTON, D.Sc., Physicist, Chudleigh, Farnborough, Hants. ..	G. W. C. Kaye ..	Sidney Russ ..	**9th April, 1918**
CAPT. H. E. GRIFFITHS, R.A.M.C., M.R.C.S.Ed., M.R.C.S., L.R.C.P., Assistant Radiographer, 11 General Hospital, Italian Expeditionary Force, V.G.	H. E. Gamlen ..	Robert Knox ..	**9th April, 1918**
CAPT. J. KESSON, R.A.M.C., Radiographer, 66 General Hospital, Italy	H. E. Gamlen ..	Robert Knox ..	**9th April, 1918**
DR. R. V. RUSHWORTH, M.C., Radiographer, Camerons Hospital, West Hartlepool and Hartlepool Hospital, Chadwell House, West Hartlepool	H. E. Gamlen ..	Robert Knox ..	**9th April, 1918**
GREGORY BRODSKY, Physicist, Bailey's Hotel, Gloucester Road, S.W.7 ..	G. W. C. Kaye ..	Robert Knox ..	**9th April, 1918**
GEORGE LUTHER GILLS, M.D., CAPT., C.A.M.C., Radiographer, C.A.M.C. Depot, Shorncliffe	A. Howard Pirie ..	Robert Knox ..	**9th April, 1918**
JAMES DUNBUEY, M.D., CAPT. C.A.M.C., Radiologist, No. XI. Canadian General Hospital	A. Howard Pirie ..	Robert Knox ..	**9th April, 1918**
J. G. R. STONE, M.B., CAPT. C.A.M.C., Radiologist, Bank of Montreal, Waterloo Place, London	A. Howard Pirie ..	Robert Knox ..	**9th April, 1918**
WILLIAM ALEXANDER COGLIN, CAPT. C.A.M.C., Radiologist, No. XI. Canadian General Hospital, Shorncliffe	A. Howard Pirie ..	Robert Knox ..	**9th April, 1918**
G. RUSSELL REID, M.D., CAPT. C.A.M.C., Radiologist, No. XI. Canadian General Hospital, Shorncliffe ..	A. Howard Pirie ..	Robert Knox ..	**9th April, 1918**
CHARLES ARTHUR ASHTON LEVER, L.R.C.S., Western Gate, Llandudno	Robert Knox ..	Geoffrey Pearce	**7th May, 1918**

NEW MEMBERS ELECTED BY BALLOT.—*Continued.*

Name.	*Proposer.*	*Seconder.*	*Date of Election.*
Miss Winifred E. Donnelly, National Physical Laboratory, Teddington..	E. A. Owen ..	G. W. C. Kaye ..	7th May, 1918
Miss Phyllis Kessick Bowes, National Physical Laborotary, Teddington	E. A. Owen ..	G. W. C. Kaye ..	7th May, 1918
James Frederick Brailsford, Radiographer to Smethwick Council and War Hospital, Smethwick, 19, Linden Road, Beawood	J. Hall-Edwards ..	Sir Oliver Lodge	7th May, 1918
Captain R. H. Sankey, R.A.M.C.I., M.B.Oxon., 35, St. Giles, Oxford ..	W. J. Turrell ..	Robert Knox ..	7th May, 1918
W. O. Overend, M.A.,M.D. Oxon, Radiologist, 29, Eversfield Place, St. Leonard's on-Sea	Robert Knox ..	G. W. C. Kaye ..	7th May, 1918
Captain J. D. Yates, R.A.M.C.,Radiographer, 38 Stationary Hospital, Italy	H. E. Gamlen ..	Robert Knox ..	7th May, 1918

NOTES.

Messrs. Thomas Illingworth & Co., Ltd., of Willesden Junction, London, N.W.10, have recently put upon the market a new medium for the production of radiographs. This is fully described in a booklet entitled "Radioprints," a copy of which may be had on application to the firm. A radioprint is a direct X-ray photograph on paper. The image produced is a negative one, similar to that produced on an X-ray plate. The result, however, is viewed by reflected light, like an ordinary photograph held in the hand or lying on a table, and not by transmitted light as are X-ray plate negatives. The method offers many advantages over ordinary plates for much work, particularly that dealing with the injuries of limbs, the localization of foreign bodies, etc., and the booklet will well repay perusal by all interested in the practice of radiography.

The British Thomson-Houston Co., Ltd., who are the owners of the British patents of the Coolidge X-ray tube, have completed a new scheme for repairing Coolidge tubes which may have been damaged or broken. Details of the scheme may be had on application to the Company at Mazda House, 77, Upper Thames Street, London, E.C.

AN APPEAL FROM THE HON. TREASURER.

In view of the demand for economy both in the direction of time, stationary, postage, etc., the Hon. Treasurer desires to make a special appeal to the members to forward their annual subscription, amounting to £1 1s., on receipt of the first application.

In former years the collection of subscriptions has only been achieved by constant application in many cases, which involves the Society in unnecessary expense.

The attention of members is directed to the fact that they can save themselves trouble and reduce the work of the Society's officials, by filling up a Banker's order form, by which their subscriptions will become automatically credited to the Society each year as they become due. A Banker's Order Form will be forwarded on application to the Hon. Treasurer.

Attention is drawn to the fact that a life membership can be obtained for a composition fee of £15 15s., and any members who wish to take up a life membership should forward £15 15s. to the Hon. Treasurer.

The new rules provide that the Society's year commences on the 1st January. Subscriptions for the year 1919 will become due on that date instead of on the 1st May following, as hitherto.

The following letter has been received by the President and he has kindly consented to its inclusion in the Journal :—

Le 31 Mai, 1918.

Monsieur le Président de la Röntgen Society, Middlesex Hospital, London, W.

Mon cher Collègue,

Notre Secrétaire général, le Dr. Haret, me transmet votre lettre, par laquelle vous nous annoncez que vous avez nommé le Président et les Membres du Bureau de la Société de Radiologie Médicale de France, Membres d'Honneur de la Röntgen Society.

Laissez-moi vous exprimer, au nom de la Société, et en mon nom personnel, tous nos plus sincères remerciements.

L'honneur que vous nous faites est très grand et nous sommes particulièrement touchés de la raison que vous invoquez, pour justifier votre décision. Il est certain que nous avons fait tout ce que nous avons pu, pour développer la Radiologie de Guerre, depuis le début des hostilités, et lui faire rendre à nos blessés, tous les services possibles. Votre appréciation est pour nous la meilleure consécration de l'utilité de notre effort, et à ce titre, nous vous remercions profondément de ce que vous avez fait.

Veuillez agréer, Monsieur le Président, l'expression de mes sentiments les plus dévoués.

(Signed) J. BELOT.

THE RÖNTGEN SOCIETY.
INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH APRIL, 1918.

EXPENDITURE.

	£	s.	d.	£	s.	d.
To Publication and Distribution of Journals	177	4	11			
,, Printing & Stationery	26	3	6			
,, Expenses of Meeting .	28	1	10			
,, Reporting (2 years) .	21	18	6			
,, Sundry Expenses, including Postages, Clerical Assistance, etc.	37	18	3			
,, Portraits of President. Balance written off ..	5	0	0			
				296	7	0
,, Silvanus Thompson "Memorial" Lecture				21	0	0
,, Dies for Memorial Medal				19	11	0
,, Honorarium to Editor (3 years)				31	10	0
,, Propaganda, moiety written off ..				25	5	1
				393	13	1
,, Balance, being Surplus of Income over Expenditure for the year ended 30th April, 1918, carried to Balance Sheet				12	15	9
				£406	8	10

INCOME.

	£	s.	d.	£	s.	d.
By Membership Subscriptions ..				268	16	0
,, Advertisements in the Journal ..	154	16	3			
,, Less Agent's Commission	38	14	0			
				116	2	3
,, Sales of the Journal				5	4	4
,, Income from Investments				16	6	3
				£406	8	10

BALANCE SHEET, 30TH APRIL, 1918.

	£	s.	d.	£	s.	d.
To Sundry Creditors ..				75	16	3
,, Accumulated Fund—Balance at 30th April, 1917 ..	462	4	8			
Add four Life Membership Subscriptions received during the year ..	63	0	0			
	525	4	8			
Add Excess of Income over Expenditure for the year ended 30th April, 1917 ..	12	15	9			
				538	0	5
				£613	16	8

	£	s.	d.	£	s.	d.
By Investments—						
£300 5% War Stock (1929-47).. ..	285	0	0			
£200 India 3% ..	139	0	0			
				424	0	0
Value as published prices at 30th April, 1918 ..	386	5	0			
,, Library				20	0	0
,, Instruments and Apparatus				12	10	0
,, Furniture				5	0	0
,, Stock of Stationery				5	0	0
,, Propaganda, Expenture in 1917-8 ..	50	10	1			
Less Moiety written off	25	5	1			
				25	5	0
,, Sundry Debtors—						
Subscriptions ..	17	17	0			
Advertisements ..	74	19	6			
				92	16	6
,, Cash in hand and at Bank				29	5	2
				£613	16	8

I have examined the above Balance Sheet, dated 30th April, 1918, and certify that it exhibits a true and correct view of the state of the Society's affairs as shown by the books and vouchers of the Society. The Bankers have certified as to the correctness of the cash balance in their hands and the Bank of England has certified as to the investments in 5 per cent. War Stock and India 3 per cent. Stock.

20, *Limes Avenue,*
*Woodside Park, London, N.*12.
31st *May,* 1918.

(Signed) E. CARRUTHERS WEBB,
Chartered Accountant.

ABSTRACTS.

269. *X-ray Spectra.* J. BRENTANO. (Archives des Sciences, 44, pp. 469-470, Dec., 1917. Paper read before the Soc. Suisse de Physique.)—The work of Beatty [Abs. 606 (1913)] points to the conclusion that the anticathodic characteristic radiation is produced, to a large extent, directly by the cathode-rays and not by fluorescence. Later research, however, indicates that the effect is solely one of fluorescence. The later researches can always be reconciled with the earlier ones by the use of particular hypotheses regarding the mode of emission ; *e.g.*, the work of Webster [Abs. 1046 (1916)] on " selective absorption " of X-rays, is an illustration of this.

The author favours the view that the characteristic X-radiation is produced directly by the cathode rays. A. B. W.

270. *X-ray Absorption Phenomena.* M. DE BROGLIE. (J. de Physique, 5, pp. 161-168, May-June, 1916.) A spectrum of the rays emitted by an X-ray bulb is obtained in the manner previously described [Abs. 1837 (1914)]. Thin screens of different substances are placed in the path of the reflected beam, and the spectra obtained show the existence of absorption bands which are characteristic of the substances interposed. These absorption bands have very sharp edges on the longer wave-lengths side, but they gradually fall off in intensity as we proceed to the shorter wave-lengths. The sharp edges of the K-absorption bands of different elements appear at the angles given in the following table, from which the corresponding wave-length may be obtained from the relation $\lambda = 5{\cdot}63 \times 10^{-8} \times \sin \alpha$, the rays being reflected from the (100) face of a crystal of rock-salt.

Element.	α	Element.	α	Element.	α
Cu	14° 15′	Ag	4° 53′	Ce	3° 02′
Se	10° 00′	Cd	4° 40′	Pt	1° 31·5′
Br	9° 20·5′	Sn	4° 16′	Au	1° 29·5′
Rb	8° 16′	Sb	4° 03·5′	Hg	1° 27·5′
Sr	7° 48′	I	3° 44′	Tl	1° 25′
Zr	6° 57′	Te	3° 54′	Pb	1° 22·5′
Nb	6° 35′	Cs	3° 26·5′	Bi	1° 20′
Mo	6° 14′	Ba	3° 18·5′	Th	about 1°
Pd	5° 07·5′	La	3° 09·5′	—	—

As many as three bands are observed in the L-radiation of some of the elements examined. The long wave-length edge of each of these bands is given in the following table ; the corresponding wave-length may be calculated by means of the relation between λ and α given above :—

Element.	Band.	α	Element.	Band.	α
Ur	1	7° 20′	Pb	2	8° 17′
	2	6° 00′		3	
	3	about 5° 45′	Tl	1	9° 58′
Th	1	7° 44′		2	8° 35′
	2	6° 22′		3	
	3	about 6° 10′	Hg	1	10° 18′
Bi	1	9° 25′	Au	1	10° 37·5′
	2	8° 01·5′		2	9° 11′
	3	about 7° 41′		3	about 8° 46′
Pb	1	9° 40′	Pt	1	10° 55·5′
			W	1	12° 26′

E.A.O.

307. *Dosimetry in X-Radiotherapy in the Services of the Army.* H. GUILLEMINOT. (Comptes Rendus, 165, pp. 462-465, Oct. 8, 1917.)—In general, sufficient account of the usefulness of the radiation at different depths is not taken into consideration. The object of the author is to make this useful effect precise and so to make possible a judicious choice of the quality of the rays employed. With any given radiation it is necessary, if the wound is superficial, that the first layers traversed by the rays shall absorb the necessary curative dose, while, on the other hand, if the skin is healthy no more than the max. harmless dose should be absorbed by it, sufficient dose being at the same time distributed to the pathological tissue to set up therapeutic action. The useful action depends only on the fixed doses. A table is given showing some types of radiation suitable for certain depths and the use of this table is fully explained. A. E. G.

308. *A New Fluorometric Apparatus for measuring Doses of Röntgen Rays.* H. GUILLEMINOT. (Comptes Rendus, 165, pp. 701-703, Nov. 19, 1917.)—The determination of the quality

of Röntgen rays can be easily carried out by means of the Benoist radiochromometer or similar apparatus, but it is much more difficult to ascertain the quantity. One of the principal sources of error is that the radiotherapy of deep-seated lesions requires very penetrating and highly filtered rays and such radiations do not act sufficiently upon chemical reagents to allow precision in dosing. The fluoroscopic method does not present the same difficulty. In the apparatus here described the object is to substitute a cheaper means for the radium standard which was used in older forms. A small circle of unpolished or opaline glass, which is divided into halves, is viewed by means of a monocular or binocular glass. One half of the unpolished glass is lighted from behind by the luminescence of a small screen of barium platinocyanide which is acted upon by the X-rays under observation, the other half is lighted by a standard electric lamp which is run on an absolutely fixed voltage and the light from which is followed to pass through blue, yellow, or green screens according to the colour of fluorescence obtained on the screen. There is an arrangement for regulating the light from the lamp from within the ratio 1 :12 about. The two principal inconveniences of such a fluorometric apparatus are : (1) there is a risk of the barium platinocyanide screen becoming brownish under the action of the rays ; (2) the luminous standard may alter with usage. These are discussed and a method of meeting the second objection is described. By using an Al filter the apparatus can also be used as a qualitometer. A table is required to ascertain the intensity of the radiation at various distances, while by means of a second table the force of penetration of the radiation, expressed in the fraction transmitted, is indicated as a function of the intensity before and after filtering. (See also preceding Abs.)

A. E. G.

380. *New Method of X-ray Crystal Analysis.* A. W. HULL. (Phys. Rev. **10**, pp. 661-696, Dec., 1917.)—A brief description of this method was given before the American Physical Society in Oct., 1916 (*ibid.* p. 85, Jan., 1917). The methods of crystal analysis that have been developed by Laue and the Braggs are applicable only to individual crystals of appreciable size, reasonably free from twinning and distortion and sufficiently developed to allow of the determination of the direction of their axes. For the majority of substances, especially the elementary ones, such crystals cannot be found in nature or in ordinary technical products, and their growth is difficult. The method which the author now describes is a modification of the Bragg method, and is applicable to *all* crystalline substances. The quantity of material required is preferably 0·005 cm³., but 1/10 of this amount is sufficient. Extreme purity of material is not required, and a large admixture (uncombined) of foreign material, 20 or even 50 per cent., is allowable, provided it is amorphous or of known crystalline structure.

The method consists in passing a narrow beam of monochromatic X-rays *through a disordered mass of small crystals* of the substance to be investigated, and photographing the diffraction pattern produced. *Disorder, as regards orientation of the small crystals, is essential.* It is attained by reducing the substance to as finely divided a form as is practicable, placing it in a thin-walled tube of glass or other amorphous material and keeping it in continuous rotation during the exposure. Thus it is assured that the average orientation of the crystalline particles is a random one. It is easily seen that the diffraction pattern will contain reflections from every possible plane in the crystal or as many of these as fall within the limits of the photographic plate.

The theory of the method is given, and the tabulated results of a large series of observations on a variety of crystals are included in the paper. Excellent reproductions of photographs are shown in the following cases : Al, Fe, Si steel, Si, Mg, graphite, and diamond.

[*Note by Abstractor.*—Debye and Scherrer [Abs. 1130 (1916)] have described a method of crystal analysis which is essentially the same as that given above by Hull. The latter, however, makes no reference to the work of Debye and Scherrer, and has evidently discovered this novel method independently.]

A. B. W.

571. *Practical Radiology in the Army.* R. DESPLATS and R. WICKHAM. (Archives d'El. Médicale, 26, pp. 67-73, Feb., 1918.)—Dausset has described a method for the localization of projectiles by means of a limited rotation and, at the same time, a variable lateral displacement of the tube parallel to the table, which can be employed with a nearly closed diaphragm. Its principal advantage seems to be the ease with which small, barely visible particles can be localized in thick regions of the body. There are, however, several disadvantages, and the method here described claims to have all the advantages of Dausset's plan without its inconveniences. The principale of the method, the application with this method of the variable rotation of the tube, and the localization of the depths of projectiles with respect to a posterior mark are dealt with in detail ; the two former are illustrated diagrammatically.

A. E. G.

Abridgments of recent Patent Specifications bearing upon the subject of X-rays and Allied Phenomena.—Compiled for publication by H. T. P. GEE, *Patent Agent, Associate I.E.E.*, 25, *Victoria Street, Westminster, London, S.W.*1, *and at* 70, *George Street, Croydon, of whom, or from the Patent Office, full copies of the Specifications may be obtained.*

112,865. *Radio-Active Substances.* HEYL, G. E., King's House, Kingsway, and BAKER, T. T., 78a, Lexham Gardens, Kensington, both in London. March 30, 1917.—For preparing radio-active water, a determined quantity of radio-active substance, such as radium barium sulphate, is enclosed in an envelope or capsule of soluble material such as gelatine.

113,483. *Radio-Active Preparations.* ELIAS, O. A., 123, Waller Road, New Cross, London. February 22, 1917.—A cotton or other absorbing medium wound on a cartridge or receptacle which is preferably secured to the tube of a syphon bottle, as described in Specification 26992/13, is impregnated with a solution of radio-active salt, dried, treated to render the radio-active material insoluble, and rendered impervious to water by treatment with an alcoholic solution of a phenolformaldehyde condensation product and by stoving for two hours at 110°C. The cartridge may be rendered self-luminous by coating with zinc sulphide. Instead of using a separate cartridge, the cotton may be wound directly on the syphon tube. Specification 10926/05 is also referred to.

114,893. *Röntgen-ray Apparatus.* GREVILLE, E. E., 167, Gray's Inn Road, London, April 19, 1917.—Relates to apparatus for the examination and treatment of patients by X-rays and comprises improvements in the table upon which the patient is laid, the stand carrying the X-ray tube, and the means for localizing foreign bodies. The table has a top which is removable and, as shown in Fig. 2, may be replaced by a stretcher D. The legs A A[1] of the table are connected by side rails C between which they may be folded, being normally held in position by removable rods E. Uprights UP UP[1], Fig. 18, with a curtain of canvas or wood WO between them, may also be attached, to one end of the table and carry supports SU, SU[1] from which a

FIG. 2.

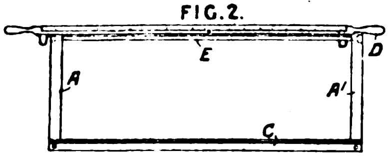
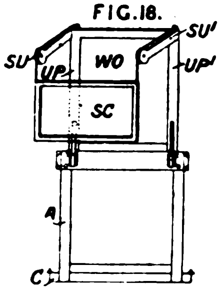
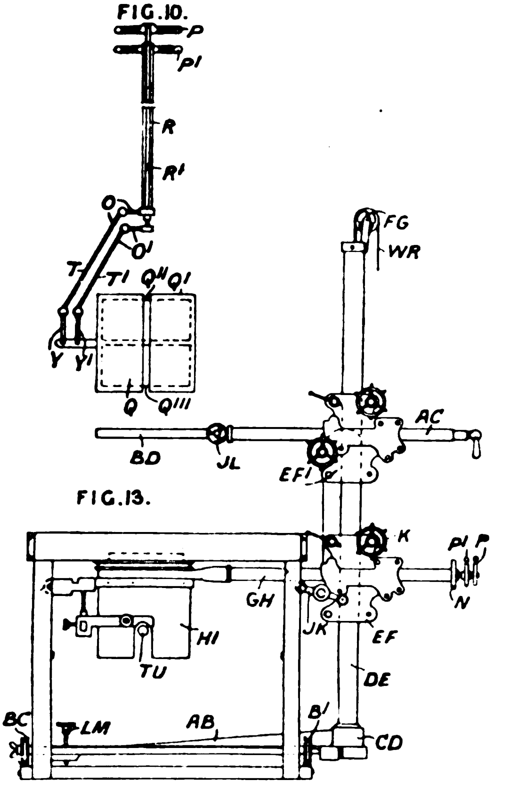


FIG. 18.



fluorescent screen SC may be suspended so that a standing patient may be examined. The tube stand comprises a base AB, Fig. 13, having wheels BC, B[1], balls, or castors, so that it may run upon the side rails C. A small roller may be hung on the spindle of the wheel BC to engage the under side of the rail to prevent the stand from becoming derailed. The base may also be provided with a screw LM so that the stand may be levelled if used apart from the table, and with a clamp by which it may be secured to the rails. An upright DE, preferably of square metal tubing, is rotatably housed in a socket CD on the base, and a cradle EF, attached by a cable WR passing over a pulley FG to a counterweight within the upright, carries a hollow arm GH which is slidable therein. A metal rod or tube within the arm GH carries the X-ray tube TU and a shield HI therefrom, and is rotatable about its axis and capable of being clamped by a nut N. Racks and pinions operated by handles JK and K are provided so that horizontal adjustment of the arm GH and vertical adjustment of the cradle EF may be effected. A second cradle EF[1] carrying a slidable hollow arm AC, within which is a rotatable rod or tube carrying a tray BD on which a screen or photographic plate is placed, may be slidably mounted on the upright DE[1] the general construction of the cradle and the parts carried thereby being similar to that of the cradle EF, etc. The tray BD may also be tilted about the axis of a clamping-screw handle JL. The upright DE is located sufficiently far from the edge of the table to enable the arm GH, when swung round parallel with the edge of the table, to be raised above it without the shield HI fouling its edge, and the adjustments provided enable the X-rays to be projected in any desired direction from either above or below the table. A gear case containing two cog-wheels connected by a chain may be applied when desired to the cradles EF, EF[1], the spindles of the pinions which engage the racks on the arms GH, AC passing through square or other holes in the centres of the cog wheels and being engaged by clips carried by the gear, case. The gear case itself then connects the cradles so that they move vertically simultaneously, and the chain and cog wheels therein cause simultaneous horizontal adjustment of the arms GH, AC. One of the pinions may be provided with a clutch so that it may be released from engagement with the rack on the arm GH when it is desired to adjust this arm independently of the other. When the apparatus is to be used for localizing foreign bodies, the arm GH is separately adjusted so that the anode of the tube is vertically below the intersection of cross wires fitted to the screen

carrier, the arms being then locked together and adjustments being made until the shadow of the foreign body falls on the intersection of the cross wires. The arm GH is then again freed and the tube moved through a known distance to obtain a second shadow, from the displacement of which the depth of the foreign body from the cross wires can be determined. The tube may be shifted a known distance without measurement by the provision of a rod secured to the arm GH parallel to its axis and passing through two fixed guides carried by the cradle, and also of a piece of metal capable of being clamped to the rod to form a stop which is brought into engagement first with the one guide and then, by sliding the arm GH, into engagement with the other guide. When the X-rays are projected from above the table downwards, the shield HI may be fitted with a conical or cylindrical compressor tube by which the abdomen of a stout patient may be compressed to reduce the thickness of tissue through which the rays must pass, the base of the stand being secured to the rails during the compression. When a diaphragm is used in connection with the tube, the leaves Q, Q[1], Q[11], Q[111], Fig. 10, thereof may be controlled in pairs by handles P, P[1], through shafts R, R[1], cranks O, O[1], links T, T[1], and arms Y, Y[1], the junctions



at each end of the links T, T[1] being preferably in the form of ball-and-socket joints. According to Provisional Specification 5503/17, the arm carrying the tube and shield may have fitted thereto a number of pieces of metal forming joints enabling the tube to be moved in any desired direction, the joints being fitted with clamps. The base of the stand may also be fitted with three or more legs so that, when the stand is used apart from the table, the wheels are clear of the floor: one of the legs, may be capable of being screwed up or down. Further, the upright of the stand may either be mounted on a base, which is detachably secured to a base permanently in position on the rails, or may be removable from the base, so that it may be fitted to another one for use apart from the table.

114,933. *X-ray Photography.* CROSLAND, G. W. K., New North Road, and CROSLAND, T. P. K., Fitzwilliam Street, both in Huddersfield. June 4, 1917.—Sensitized paper or like flexible materials for obtaining direct X-ray photographs or radiograms is covered or coated with a paint or wash of Venetian red, chrome yellow, or like preparation to form an opaque protecting medium over the sensitized surface and over the back of the paper, etc.

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THE RÖNTGEN SOCIETY.

RÖNTGEN SOCIETY.

A General Meeting was held at the Royal Society of Arts on May 7th, the President, Captain G. W. C. Kaye, M.A., D.Sc., in the chair.

The minutes of the last meeting having been taken as read, some nominations were read for the first time, and the following were balloted for and elected members of the Society:—

Charles Arthur Ashton Lever, L.R.C.S., Llandudno
Miss Winifred E. Donnelly, Teddington.
Miss Phyllis Kessick Bowes, Teddington.
James Frederick Brailsford, Smethwick.
Capt. R. H. Sankey, R.A.M.C.I., M.B., Oxford.
W. O. Overend. M.A., M.D., St. Leonards-on-Sea.
Captain J. D. Yates, R.A.M.C., 38 Stationary Hospital, Italy.

DISCUSSION OF THE PROPOSED NEW RULES OF THE SOCIETY.

The PRESIDENT said that the programme of that meeting was somewhat unusual; apparently it was not viewed by the majority of members as very fascinating, but it was one of those inevitable things which cropped up from time to time.

The Council thought it wise to try and put the Society's house in order, and had spent two long and careful meetings in considering the draft of the new rules. It was intended that these new rules should have been circulated more than a month ago in order to comply with the existing statute, but printing nowadays was extraordinarily difficult, and in this case there had been quite a calamity, for the printers got the rules into proof when the premises were commandeered by the Government. Although eventually they managed to get out the draft which members had in their hands it was too late to comply with the existing rules, so that the meeting that evening could not ratify the rules, and another meeting would be necessary. He proposed, therefore, that an informal discussion of the rules, one or two of which were controversial, should take place that evening, and at the next meeting it might be possible for them to be passed more or less *en bloc*, and thus finish up the work of the session. The first rule concerned the proposed change of the Society's name. On this point the Council found itself unable to make up its mind, and it was thought much better to have an expression of opinion from the Society generally. It had been hoped to secure a general expression of opinion by means of a post-card, but that again proved to be impossible.

Professor A. W. PORTER said that as the Council had been unable to make up its mind as to what the best name would be, it struck him as rather questionable whether this was the most opportune moment to effect such a change. The Society had grown accustomed to its existing name, and he was not quite sure as to the object of the proposed alteration. If it was connected at all with international complications, they could hardly look upon it at the moment with the calm judgment which such a big change required. Perhaps later on in more peaceable times it might be considered advisable that some change should be made, and he would support a change under such circumstances. At the present time it was scarcely wise for a Society which had now got its footing and was known throughout the world to do anything which might perhaps be subject to a misinterpretation. He proposed that the change of name be postponed.

Dr. G. H. RODMAN seconded the proposition. He thought that it was certainly an inopportune moment to change the name of the Society, and that the Society had been so great a success under its old name that it was a thousand pities to change it at all.

Dr. G. B. BATTEN thought it would be a help to the meeting if the Chairman or some of those who had proposed the change of name should tell them why the change was suggested. It certainly was not for international reasons. One reason was that the name Röntgen Society did not include everything that the Society did. The Röntgen Society was associated in the minds of everybody with X-rays, but the Society discussed a great many other subjects.

Mr. C. A. CLARKE pointed out that the name "Röntgen Society" scarcely covered section (b) of the Society's objects, "to promote the study of radioactivity, electricity, and other branches of physics, especially in their relation to medical science."

Mr. W. E. SCHALL said that as regarded the motive for which the change was being made, surely it was not so much that they knew why the change was being made as that people outside would form wrong opinions as to the reason for the change at such a time. Early in the war some learned professors in Germany issued a document in which they condemned England and made certain wild statements,

but he was told that those same professors had departed from that position already, and were very sorry they had signed anything of the kind. He felt that the Society ought not to do anything, however sincere its intentions, which could be taken by the world at large as due to political feelings of any kind. For that reason he thought that they ought to postpone any change of name until some time after the war.

Dr. W. A. HAMPSON agreed with the idea set forth by Professor Porter. It was a very great pity the name should be changed, although, inconsistent as it might seem, he had had a considerable hand in formulating the new names offered for their choice. He understood that the Society wanted a name which should fully set forth its purpose, and it was decided to give the Society the choice of three names. But he would prefer to have no change of name at all, and he thought that the Society stood to lose a great deal by giving up the name which was an honoured one and which did no more than justice to the gentleman who possessed it. To express international feelings at this moment in the name of a learned society was too small an action and rather too closely characteristic of learned German professors for them to imitate. It would be a pity to forfeit the wide connection which the Society possessed by virtue of its existing name.

Mr. W. F. HIGGINS said that the name "Röntgen Society" appeared (in brackets) in the two newly suggested names. As regards the time, this was the time to change the name in view of the fact that they were proposing new rules, for it was obviously more satisfactory to have the change of name at the time the rules were changed. "The Society of Radiology" or "The Society of Radiology and Electrology" gave some idea of the nature of the work in which the Society was interested. In suggesting these names, another point should be borne in mind, namely, that it might be possible at some time in the future to get a royal charter, and therefore it would be well to have a name before which the word "Royal" could be introduced. One could have a Royal Society of Radiology, but not a Royal Röntgen Society.

Capt. ROBERT KNOX said that he did not see at all why they should not change the name, and he thought the present time very opportune. They had eliminated the name of Professor Röntgen and two other German names from their list of honorary members, and the course suggested at that meeting was the natural corollary of such action. The only difficulty was to get a suitable name. He supposed they could not have the "Crookes Society"; it would lend itself to the "Society of Crooks" (laughter). He thought it a very opportune time to change the name as a real expression of their opinion as to the German nation. The Society of Radiology would be a very good name, and the words "Röntgen Society" could be left in, in brackets, just to please the feelings of some of the members.

Mr. GEOFFREY PEARCE associated himself with the views of Captain Knox and Mr. Higgins. One sufficient reason why he would change the name was because Röntgen was a German.

Dr. RODMAN : Of Dutch origin.

Mr. PEARCE : But a professor at a German university. Why they should perpetuate the name of a German he could not understand. If the Society had flourished under this name, it was not because of the name that it had flourished. In addition to this, the term "Röntgen" did not define the scope of the Society.

Professor PORTER said that if an application for a royal charter was contemplated, the obvious time to change the name was when such charter was granted.

The PRESIDENT said that he must admit right away that he was responsible for stirring up this strife. He thought that the Society had outgrown its name. It dealt with a number of other things besides X-rays. A restricted name like Röntgen Society did them no justice. They wanted to indicate the fact that they were a Society which dealt with radiations. He thought of the "Radiation Society" and other titles. As for the argument that the name belonged to a German, this only had the effect of hardening his opinion. The trend of events had made them all patriots or pacifists. Such criminal events as had taken place in this war had never stained the world's history before. He thought that the change of name would have the effect of removing all taint of Germanism from the Society.

A vote was then taken. The adoption of the term "The Society of Radiology and Electrology (Röntgen Society)" found four supporters; "The Society of Radiology (Röntgen Society)" found fifteen; and "The Röntgen Society" as at present, seven. It was stated that this decision was not binding, but was subject to ratification on the next occasion.

Dr. G. H. RODMAN then raised the point with regard to the postal vote. He said that at the Council, in deference to the President's wish, he undertook to withdraw his proposition on the understanding that a postal vote should be taken on the point, including on the post-card the names as appearing on the printed list. He was now inclined to press for that postal vote before a decision of such far-reaching importance was finally made.

Dr. J. W. METCALFE seconded the proposition that a postal vote be taken. That small meeting was not justified in deciding even in a tentative way on a change of name. The matter ought to be put straight before the membership.

The PRESIDENT said that according to the rules no postal vote could be binding, but the result of that postal vote would afford the strongest guidance to the next meeting.

Rules 2, 3 and 4 were then passed, on the motion of Dr. Metcalfe, without discussion.

On the proposed Rule (5): Qualification for Ordinary Membership,

Mr. F. H. GLEW said that he was sorry to break in on a contentious matter, but it seemed to him that there was a great deal more in this Rule (5) than appeared on the surface. He very strongly objected to a scientific society being made use of in the interests of any section of that society. This rule seemed to him likely—indeed, he knew positively that it would be so—to exclude some very honourable men who were at present doing X-ray work in a most useful way to the nation at large, and were doing it under no legal disability whatever. It was not for a scientific society to imply a censure or to cast any reflection upon such men. It seemed to him, therefore, quite unnecessary to impose this restriction upon X-ray workers who were not duly qualified practitioners. He himself could say from twenty-one years' experience as a member of the Society that it was perfectly obvious that the medical men had had twenty-one years in which to serve the nation with the splendid discovery of X-rays for the alleviation of human suffering, and yet the result was that at the present moment they were incapable of meeting the needs of the nation in respect to radiography. He himself had practised as a surgical radiographer for twenty-one years, and without any egotism he could say that he had been a very useful member of the community, and if he had no other consolation on his deathbed he would be content to think that he had served his country in more than one way

conscientiously and usefully. He appealed to the scientific members of the Society, who were probably unaware of these things, not to allow the medical section to take advantage as they were doing by such a rule as this ; there was no other word for it. Take hospitals again ; there the laymen practically did the work. There was supervision, it was true, but it was nominal supervision in many cases. If laymen were not to do the work then a great deal of suffering would take place as a result of the work not being done. They must not tell him that a layman was incapable of radiographing a broken limb. When one came to the higher branches of radiography, in expert diagnosis dependent on the use of a bismuth meal, in the detection of heart troubles, and in the more refined work, then he said that the ordinary man like himself ought not to touch it ; such work ought to be sent to a man who had made it a special branch. That was altogether a different thing. There must be specialism. Amongst themselves they must specialize. But this method of excluding laymen from the Society was quite unnecessary. The later rules as to expulsion and the fact that all nominations had to come before the Council were quite sufficient to exclude any undesirable applicant. That had operated in the past quite successfully, and it was unnecessary to depart from it now. Every case ought to be treated on its merits. He thought he had shown that the new rule was unnecessary and undesirable, and he would ask the Society later on, as this was an informal meeting, to delete it.

Professor PORTER said that he had no personal interest in this question, and therefore he could not speak with the earnestness of Mr. Glew. But in principle he thought he agreed entirely with the remarks he had made and the objections he had urged against the institution of this new rule. He believed it was recognised that they were not a medical society. The old Electrotherapeutic Society was one which was distinctly medical, and it was perfectly justifiable on the part of that Society to institute what restrictions it liked upon its membership. But the Röntgen Society was essentially a Society in which medical men and physicists joined together for mutual discussion, and it did seem to him not the right thing to institute any restriction upon one part of the membership. This was not a medical society, and they had really no right to discuss purely medical questions. Nor had they anything to do with the medical qualifications of any one of their members. That was really a question for the General Medical Council. If the Medical Council liked to take up the question as to whether an unqualified man should make radiographic examinations, then it was its duty to do so, but it was not the duty of that Society. He confessed that he was rather sorry to see the proposed rule. Any man admitted to that Society should be admitted on account of his scientific knowledge. That was really the plan which would most readily fuse together the two separate interests, the medical and physical interests with which the Society had occupied itself. But the institution of such a rule as this would cause disruption between the two ; things would not work so harmoniously as in the past. They as a Society had got no more to do with the medical qualifications of a candidate for election than they had to do with his political views.

Dr. METCALFE said that the whole question resolved itself into one of ethical conduct. The Society was not a medical society, but its objects were distinctly stated as being "to promote the study of radioactivity . . . especially in their relation to medical science." They could not honestly apply these methods in connection with the investigation and study of disease unless they had a trained

medical mind. That had nothing whatever to do with Mr. Glew's contention that all medical men were not able to do this class of work. Heaps of medical men were not able to do eye, ear and throat work, but then a proper knowledge of anatomy, physiology and chemistry was necessary to a proper method of diagnosis. He (the speaker) maintained that one could not diagnose disease unless one had had a proper training in all those collateral branches of medical science. The whole thing resolved itself into a question either of genuine honest work or of empiricism. This Society was surely not going to be known as a society for the protection of empiricism, a society that was going to give its support to men who had not and could not have any competent knowledge of a subject of this intricacy. Mr. Glew had said that the higher branches must be reserved for others, but he (the speaker) maintained that the lower branches also ought to be reserved. Could Mr. Glew diagnose multiple diseases of the joints and bones? Could he arrive even at the importance of fracture without medical knowledge? He made no reflection upon Mr. Glew, save that on this point he did not understand the position. He could not properly diagnose disease, nor come to a proper conclusion as to its findings. This was going to become a serious question after this war—all sorts of people doing work they ought not to do, and treating disease when they were not at all qualified to do so, and as this Society was now proposing new rules for future use it ought to be extremely careful to have a new rule of this character to protect it from the suspicion that it in any way upheld unqualified practice.

Dr. HERNAMAN-JOHNSON said that this was really a matter of principle. The unfortunate fact that in many towns medical men would not send their work to another man in general practice in the same town was not an argument of principle at all. It might be argued that the medical practitioner concerned should be confined to his X-ray work, or that medical men should send to him as a matter of rule. But two wrongs did not make a right, and there was no reason why these professional jealousies should be allowed to interfere with the position at all. The Society did contain a strong medical element, and he did not see how the medical men could continue to be associated intimately with the Society if it recognised amongst its members unqualified practitioners. Professor Porter had said that the new rule would lead to disruption. It was much more likely that the non-acceptance of it would lead to disruption in the sense of a breakaway of the medical section from the Society. As medical radiologists they could not continue to be associated with men in unqualified practice. Their own views of ethics in this particular respect would be distinctly traversed. Existing members, of course, were on a totally different footing. When X-rays were first discovered they were taken up by pharmacists and others who did extremely useful work. But the matter had got far beyond that stage now, and it was impossible to draw a dividing line between what was readily diagnosable and a commencing sarcoma for instance, the missing of which might mean the losing of life.

Dr. G. B. BATTEN said that it was with mixed feelings he spoke on this question. A long time was spent in the Council on the matter, and this rule was really the result of a majority of Council. His own feeling in the matter was simply this: He remembered this Society from very early days, when they had medical and scientific papers, and it soon became clear that a mixed society was not a society where purely medical papers should be read, and in fact they did not interest the other members very much. Some members, including Dr. Chisholm Williams,

thereupon founded the Electrotherapeutic Society. Great pressure was brought to bear upon him (the speaker) to leave the Röntgen Society because medical matters were discussed; nevertheless, he retained his membership. Many of the men had now returned to the Society because the Society studied what the new rules described as radioactivity, electricity and other branches of physics, especially in their relation to medical science. The older members, of whom Mr. Glew was an example, had done most useful work, and he thought that if they were to leave the Society they would leave it under a misapprehension. What many felt was this: they did not wish to be associated with a Society which threw its ægis over people who professed to do that which they were unable to do. He would much rather if he were going to have his hand X-rayed or even his kidney X-rayed have it done by Mr. Glew than by many of the hundreds of medical men who had only learned X-rays during the last twelve months. But he would distrust altogether Mr. Glew's or any non-medical opinion as to what the photograph meant. He would rather have the opinion of a medical man who had perhaps only done X-rays for six months. There were hundreds, even thousands, of lay assistants in military hospitals who, immediately after the war, were going to be thrown out of work. It was those people of whom he was frightened; not jealous professionally, but they were people who had learned the art of X-rays without knowing anything about the medical science of interpretation. He himself was a general practitioner, and his X-ray work was only a quarter of his entire work. He happened to be a specialist in the X-ray treatment of ringworm; he was the first to do it in this country. Most of the ringworm work in the hospitals was done by lay assistants controlled by medical men. Now, the X-ray treatment of ringworm was a highly technical matter. If one had a tube set exactly right and was doing it every day and got to know tint B well perfectly, the layman would be able to do the work quite as well as the doctor. But if the tube punctured and had to be reset, the inexperienced hand in resetting would very quickly be the means of bringing about baldness and dermatitis. There were scores, even hundreds, of lay assistants who were carrying out that treatment under medical men, and who were incapable of doing it without such medical supervision. He himself sent a good many of his X-ray diagnosis cases to X-ray specialists who were efficient in the things in which he himself was not efficient, in heart diagnosis, for instance, where he had not the opportunity of seeing very many cases, so that he was far from claiming the omniscience of every medical man. He hoped the rule would be passed. It would regulate the Council's procedure with regard to such cases, whereas at present they hardly knew what to do with them.

Mr. W. E. SCHÅLL pointed out that the Council was to admit laymen who acted as assistants to doctors. If after the war these men set up for themselves what would be the attitude of the Council towards them. Would it start a policy of expulsion?

Professor PORTER said that a man might be guilty of unethical conduct in any one of a great number of ways. Why not, therefore, specify them all in Rule 5 if one was to be specified?

The President then put the acceptance of Rule 5 as drafted to the vote, and it was carried by thirteen votes to five.

Rules up to 19 were carried without discussion. After some discussion on Rule 20 (d), in the course of which Dr. Batten wanted the three years changed for four, and Dr. Rodman to six, the President said that the Council was under some stigma

as a close preserve, and it was only right to give the new members a chance of coming on. A motion by Professor Porter that the word "ordinarily" be inserted to give a loophole to exceptional treatment, so that the rule would run, "Ordinary members of Council shall not ordinarily serve longer than three years consecutively, the four senior members retiring each year," was agreed to.

Some discussion as to the possibility of taking a postal vote with regard to any future alteration of the rules (Rule 35) ended indefinitely without a vote being taken and the President in adjourning the meeting said that the rules would come up for confirmation on June 4th.

RÖNTGEN SOCIETY.

The Annual General Meeting was held at the Royal Society of Arts on Tuesday, June 4th, Dr. G. H. Rodman in the chair.

The minutes of the previous ordinary meeting were read and confirmed, and a ballot was taken for the candidates whose names were given on the agenda paper, and these were elected *en bloc*. The Chairman pointed out that during the past year no fewer than ninety-nine new members had been elected.

The minutes of the last annual general meeting were taken as read.

Dr. RUSS read the annual report of the Council for the past year.

Mr. P. J. NEATE moved the adoption of the report and congratulated the governing body upon the great success of the year's work. This was formally seconded by a member of the audience and carried *nemine contradicente*.

Mr. GEOFFREY PEARCE read the Treasurer's report.

Dr. G. B. BATTEN moved the adoption of the report, and this was seconded by **Mr. W. F. HIGGINS,** and agreed to.

The ballot for officers and Council was then proceeded with, Mr. Head and Mr. Schall acting as scrutineers. The names as given on the ballot paper were elected without alteration as follows:—

President: G. B. Batten, M.D., C.M.

Vice-Presidents: J. Hall Edwards, M.R.C.S., Professor A. W. Porter, D.Sc., F.R.S., Dawson Turner, M.D.

Members of Council:

C. A. Clarke, L.D.S.	J. W. Nicholson, M.A., D.Sc.
N. S. Finzi, M.B.	G. H. Rodman, M.D.
W. Hampson, M.A., L.M., M.S.A.	W. E. Schall, B.Sc.
Howard C. Head	E. S. Worrall, M.R.C.S.
C. R. C. Lyster, M.R.C.S.	E. P. Cumberbatch, M.A., M.B.
J. Metcalfe, M.D.	V. E. A. Pullen, D.Sc.

Honorary Treasurer: Geoffrey Pearce.

Honorary Secretaries: Robert Knox, M.D., Sidney Russ, D.Sc.

Editor of Journal: W. F. Higgins, M.Sc.

The CHAIRMAN suggested that the appointment of a sub-editor or co-editor might be left to members of the Council. A member of the Council had been nominated for that position, but it was uncertain at the moment as to whether he would consent to serve.

Mr. SCHALL asked at what General Meeting Professor Röntgen was deprived of the honorary membership of the Society.

Dr. KNOX said that he had not the information available at the moment.

Mr. SCHALL said that he did not question the decision, but he thought the Society ought to be given a chance of expressing an opinion before such a step was taken.

The CHAIRMAN suggested that in view of the absence of records, the matter might stand over and be brought up at a subsequent meeting, and Mr. Schall consented to that course.

The CHAIRMAN welcomed Dr. Batten, a member of nearly twenty years' standing, to the position of President. He felt that under his leadership the success of the Society during the coming session was assured. He congratulated the members on making the selection they had done.

Dr. BATTEN acknowledged the compliment.

The CHAIRMAN said that two members, Mr. Harrison Glew and Mr. Patterson, had received the Order of the British Empire (applause).

Mr. GLEW said that whatever honour had been paid him had been the result of his association with the Society.

The CHAIRMAN then made the presentation of a stand camera to Mr. J. H. Gardiner on his resignation of the position of editor of the Journal, which he had held for the past fifteen years. It was felt by the members of the Council that the occasion should not be allowed to pass without some definite recognition of Mr. Gardiner's services, so well and truly rendered in the interests of the Society.

Mr. J. H. GARDINER, in receiving the gift, thanked the members for their kindness, and said that the present was one which would afford him a great deal of pleasure. He would like to say that the success of the Journal depended entirely upon the work of the Society. The Journal could not run itself. The Editor of the Journal could only work up the matter which was offered him, and he trusted that continued efforts would be forthcoming to make the work of the Society well worth reporting.

REVISION OF THE RULES OF THE SOCIETY.

On the further discussion of the revision of the Rules of the Society, to the discussion of which the previous meeting (May) had been devoted,

The CHAIRMAN announced, with regard to the first Rule dealing with the name of the Society, that in the post-card vote which had been taken eighty replies had been received, and of these thirty-five were in favour of the retention of the present name ; twenty-five were in favour of a change of name to The Society of Radiology (Röntgen Society), and twenty were in favour of the name Society of Radiology and Electrology (Röntgen Society).

Dr. BATTEN proposed that the name of the Society should be altered to " The Society of Radiology (Röntgen Society)," but on being put to the vote this motion failed to secure the requisite two-thirds majority, and the second suggested name, " The Soceity of Radiology and Electrology (Röntgen Society) " had even less support, so that in the result it was agreed that the old name, Röntgen Society, should remain.

Rules 2, 3 and 4 were then passed without discussion, and on Rule 5

The CHAIRMAN said that the eligibility of unqualified persons actually practising radiology had engaged the attention of the Council for the last few months, and it was felt advisable to submit a new Rule on the subject to the Annual General Meeting

But during the previous week a proposition which seemed to make it rather less drastic had been put forward, and this was offered in substitution for the portion of the original Rule to which objection was taken at the last meeting. The amended portion ran as follows :—

> No person engaged in the practice of medical or surgical radiography shall be eligible for the membership unless he or she is proposed or seconded by a medical practitioner, who must have personal knowledge of the candidate, the final decision to rest with the Council. No person engaged in therapeutic work shall be eligible for the membership unless duly qualified in medicine. This rule shall not, however, exclude bona-fide assistants to qualified practitioners, and it shall also not be made retrospective from the date of the passing of these rules.

The CHAIRMAN moved the adoption of this new Rule as amended.

Mr. F. H. GLEW said that at the last meeting he expressed his views pretty fully on the nature of the proposed change, to which he was very much opposed on the ground that it was too drastic. It did seem to cast a reflection on those medically unqualified people who had done radiography, so that he was very glad indeed to see the proposed alteration, which did not have quite the same effect. He would very much like to see the medical profession having a service right through the country which would provide for the needs of rich and poor alike. He could not acquiesce in any change of the rules of the Society which was going to cast an unjust reflection, particularly on the old members of the Society, because on going back upon the Society's history, all those who remembered the old days would realize that the lay members were very useful members indeed. Unfortunately there were few doctors like Dr. Batten, who understood the technical and electrical side, while many laymen, such as Mr. Isenthal, and the late Treasurer of the Society, had done excellent work. To bring X-rays within the reach of all would be a good thing for the nation, but at present such a service did not exist. He was glad that the rule had been found capable of modification.

Dr. BATTEN said that he was glad that at last, after many nights' discussion, they had got a rule which, he thought, would satisfy the medical man on the one hand and Mr. Glew and his friends on the other. He felt that, as a Society, they did not want to discourage the lay worker ; they only wanted to discourage him when he proposed to do something that he could not do.

The motion to adopt the rule as amended was then put to the meeting and carried, with two dissentients.

The remaining rules were adopted without discussion.

Mr. N. E. LEBOSHAY then delivered an address, illustrated by the exhibition of negatives and apparatus, on "An Investigation of the Photographic Action of X-rays." As the hour was late, owing to the pressure of the preliminary business, Mr. Leboshay had to forego a portion of his lecture.

He said that he proposed to tell them, in a very few words, what he had been doing and the direction in which he had worked. In all that he did with regard to X-ray work, he was checked by the best advice he could get—namely, that of Dr. Knox, the Honorary Secretary of the Society. He was also helped by the Kodak Research Laboratory, and only the previous day had received an intimation from Dr. Mees, though on this occasion it was to the effect that something for which he had asked could not be got.

He proceeded to show the results of a method of development which he had previously carried out in his own dark-room. He was strongly of opinion that with ordinary methods of development they did not get all the image that was to be got, and indeed lost something that was already there. One drawback was that so little was known upon the photographic side of X-ray work, and while it was true that among the various plates on the market there was no such thing as a best plate, because all were good, yet the plate suffered in certain respects because the manufacturers did not know exactly what was wanted from them. They were confronted with the problem of getting out by plain development a photographic image not impressed upon the film surface, as in the ordinary case, but embedded in the whole thickness of the film. They had to develop the image, not only as it were on the top, but at the bottom of the gelatine as well. There was no literature known on the subject which gave a direct method of getting an image which was not on the surface of the film. It was generally taken that in the first place they had to employ a very strongly concentrated developer, and in order that this strongly concentrated developer might not fog the emulsion they had to use a restrainer like bromide. This was the wrong way about. There was also the trouble with regard to secondary radiation, although about this he had his doubts. He wondered how much was secondary radiation and how much was fog on X-ray plates, and he thought he had succeeded in getting a little more light on the subject, although he was still far from the final result.

Coming to his experiment, he said that he had asked Dr. Russ to give him a number of plates exposed for increasing lengths of time, from deliberate under-exposure to considerable over-exposure, and by careful development he found that the X-ray plate lent itself even better than the ordinary plate to get an average result. There were ten plates in this experiment, all of them of the same variety, and exposed to Coolidge radiation for, respectively, 2, 4, 6, 8, 10, 15, 20, 35, 45 and 60 seconds under identical conditions. Which of these would Dr. Russ describe as correctly exposed ? (**Dr. RUSS :** I have not the remotest idea). Mr. Leboshay here passed round the results. Dr. Batten, after examining them, said that in his opinion they were all good except the first two (i.e., those which had received 2 and 4 seconds' exposure). Mr. Leboshay said that if one took these two thin negatives and superimposed them one had the equivalent in density and detail of an exposure of 15 seconds. Such, then, was the latitude of exposure, and even two seconds' exposure gave quite a considerable amount of detail. All that he had done in order to secure this closely averaged result was to correct the development by simple dilution with water. He carried out tank development which permitted the developer to retain its potency all the time that development was proceeding without being oxidized by the air. He had used normal metol-hydroquinone developer, diluting it so much with water, and nothing more or less. All the plates were treated alike, and he could bring development up to an hour or bring it down to 15 minutes just by making it weaker or stronger according to the dilution. Thus he arrived at a knowledge of the maximum and the minimum that the developer could do. In passing he said that he was entirely in favour of vertical as against horizontal development, and he showed the construction of a tank in which the development was carried out, and commented upon its air-tightness and light-tightness. The development in the case of the experimental plates lasted for 22 minutes, and all were developed exactly alike. He acted on the principle which had often commended itself

to him in ordinary photographic work. If he got an image which was under-exposed, and the details in the shadows were wanted, he diluted his developer and got those details by not allowing the high-lights to "run away with him." If he robbed that developer of its energy by the addition of a restrainer, he did not give it a chance to do so, and that was what water did. Dilution with water had more effect on the ratio of the tones than any change in the ingredients of the developer. In that way he had often saved many hopelessly over-exposed plates by continuing development with a weakened developer, although he saw nothing of the details. X-ray work offered a more favourable field for such experiments than did ordinary photography, and the thinning of the developer as he practised it gave quite good results. He was of opinion that a great many of the ill-effects which were put down to secondary radiation were really due to fog caused by unscientific development. With the due appreciation of the photographic problems involved in X-ray work, he did not see why there should not be new possibilities in radiography. He did not see why the different layers of muscles should not show a different ratio of transparency from a calculus. He thought that the calculus, no matter how similar it might be to its surroundings, should be differentiated by proper methods both of choice of tube and development. He thought also that the panchromatic plate would play a great part in distinguishing things which had hitherto been invisible or not certainly visible to X-rays, and by selecting certain metallic filters they were likely to be able to separate one part from another sufficiently to differentiate and get a better impression of calculus or gallstones. He hoped to see development so well standardized that it would be impossible for anyone to make a mistake, although the experimentation and research on this subject was very slow work. Mr. Leboshay then went on to describe and exhibit some photometers which he had constructed, the most promising of which was composed of optical glass in different layers.

At this point the Chairman said that there was so much of interest in what Mr. Leboshay had to tell them that it would be more politic in view of the lateness of the hour if they adjourned the meeting at that point, and induced Mr. Leboshay to come again early next session, when he could devote an entire evening to the subject, instead of the truncated evening which he had had on that occasion.

Those present signified their pleasure at this course, and a vote of thanks was accorded to Mr. Leboshay by acclamation.

ANNUAL REPORT.

The Session that is now brought to a close has in many ways been a remarkable one. It is particularly fitting that the twenty-first year of our Society should be distinguished by a record of activity and general virility that has never previously been equalled.

The year has brought its losses as well as its gains. We have to deplore the death of two of our Past Presidents, Mr. W. Duddell and Mr. Wilson Noble, whose work is so well known to you all. The death of our Foreign Corresponding Member, Dr. Jean Clunet, is a great loss to the Society. Resignations during the year have been few, but mention must be made of the retirement of Mr. Gardiner after fifteen years' valuable and untiring service as Editor of the Journal.

How much of the quickening spirit which has been so evident a feature of the

work of the Society during the past year has been due to our President may, of course, be inferred by the members, but only thoroughly realized by those more concerned with the inner workings of the Society.

The year has been full of work of reconstruction and of innovations ; attractive as many of these are even at first sight and acquaintance, their benefits to the Society will be more and more felt as time goes on.

Dealing first with the innovations we have to record the founding of a Silvanus Thompson Memorial Lecture and Medal, and there can be no doubt as to the fitness of thus honouring our first President. The first lecture, delivered by Sir Ernest Rutherford on April 9th, was a pronounced success.

A Benevolent Fund has been started and subscriptions are already coming in.

The most important work of a reconstructive character which has been put into effect is that concerning the Journal, which has been remodelled by the new Editorial Board, the means taken (in the form of an attractive brochure) to make known the aims and objects of the Society to the world at large, and the entire recasting of the Rules of the Society, which had in many particulars become obsolete.

Another new move on the part of the Society is the initiation and formation of an Advisory Board, the function of which is to advise on matters concerning the X-ray industry. This Advisory Board has already had several meetings and done useful work.

Additions to our list of Honorary Members during the past year include Sir J. J. Thomson, Professor W. H. Bragg and Dr. W. Coolidge.

The Council is taking steps to bring up to date the Historic Collection of X-ray bulbs belonging to the Society.

Passing now to the meetings of the Society, the papers have dealt with practically every interest that the Society holds and were as follows :—

"Absorption Spectra of X-rays." Prof. J. W. Nicholson, M.A., D.Sc., F.R.S.

"The Region of the Ultra-violet Spectrum of Greatest Therapeutical Effects." C. A. Schunck, F.C.S.

"A Portable Röntgen-ray Generating Unit." W. D. Coolidge and C. N. Moore.

"A New Radiator Type of Hot Cathode X-ray Tube." W. D. Coolidge.

"A Simple Means of obtaining 'Static Modalities' from an Induction Coil." G. B. Batten, M.D., C.M.

"A Mobile Snook Apparatus." E. E. Burnside.

"A Biological Basis for Protection against X-rays." C. R. C. Lyster, M.R.C.S., and Sidney Russ, D.Sc.

"A Mobile X-ray Unit." Howard C Head.

"An Investigation of the Photographic Action of X-rays." N. E. Leboshey.

The number of new members during the Session 1917-1918 is ninety-nine, which is nineteen in excess of the total number of members elected during the whole of the three preceding years. The membership of the Society now stands at 315.

With regard to the financial security of the Society it is only to be recorded that owing to the unfailing exertions of our Honorary Treasurer our investments and balance of moneys in hand are at high water mark.

HON. TREASURER'S REPORT.

I have the pleasure to submit to the members of the Röntgen Society the balance sheet and accounts for the year ended 30th April, 1918, and it will be observed that

the income appears as £406 8s. 10d., or a surplus of £12 15s. 9d. over expenditure, which amounts to £393 13s. 1d. The latter figure is exceptionally heavy owing to an inevitable increase in the cost of printing, stationery, etc., in addition to which abnormal expenditure has been incurred, namely, £25 5s. 1d. for expenses of propaganda, £31 10s., three years' honorarium to the Editor, and the charge of £19 11s. for dies for the " Silvanus Thompson " Memorial, which has been entirely written off in this year's accounts. We have also had to meet for the first time what will in future be an annual charge of 20 guineas for the " Silvanus Thompson " Memorial Lecture.

During the year under review four Life Membership Subscriptions have been received and these, as before, have been added to the accumulated fund on the balance sheet which, with the surplus for 1917-8, now amounts to £538 0s. 5d.

In consequence of representations having been made to the Council of an old member in distress, it was decided to establish a Benevolent Fund to assist cases of this nature. A few subscriptions have been received which, it is expected, will form a nucleus and this will be administered for the benefit of such members.

Taking all special circumstances into consideration, our balance sheet may be regarded as satisfactory as those of previous years.

GEOFFREY PEARCE, Hon. Treasurer.

RÖNTGEN SOCIETY.

NEW RULES OF THE SOCIETY.

A. NAME AND OBJECTS.

(1) **Name.**—The name of the Society shall be—" The Rontgen Society."

(2) **Objects.**—The objects of the Society shall be :—

(a) To promote the study of X-rays in all its aspects

(b) To promote the study of Radioactivity, Electricity and other branches of Physics, especially in their relation to medical science

(c) To hold periodical meetings for the reading of papers on, and the discussion of all matters arising out of sections (a) and (b) of this rule.

(d) To publish a Journal wherein the proceedings of the Society shall be recorded.

(e) To maintain a Library and to provide such facilities for the study of the above subjects, as may, from time to time, be, in the opinion of the Council, desirable.

B. CONSTITUTION AND MEMBERSHIP.

(3) **Constitution.**—The Society shall consist of members of either sex, comprising

(a) Honorary Members,

(b) Honorary Corresponding Members,

(c) Ordinary Members.

(4) **Qualifications for Honorary Membership.**—Honorary members of classes (a) or (b) shall be selected by the Council in recognition of special distinction, in this country or abroad, in the work dealt with by the Society.

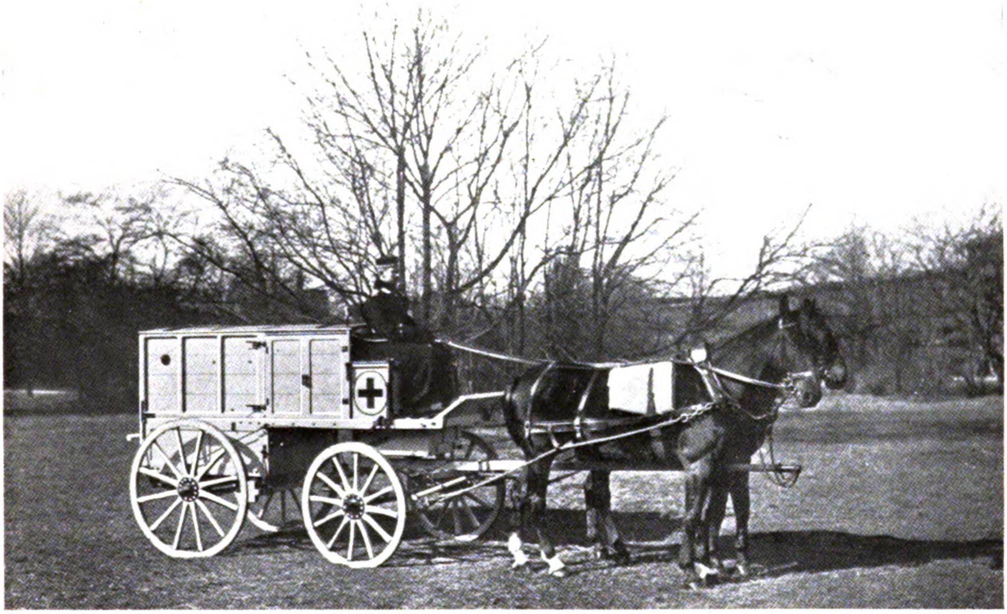

Fig. 1.—Military X-Ray Cart as used by Continental Armies.

This Outfit consists of a Benzine-Dynamo and a large X-Ray Apparatus, complete with the necessary accessories for screen and radiographic work, as well as for illuminating the operating tent. The X-Ray Apparatus is also suitable for connecting up to any other source of supply.

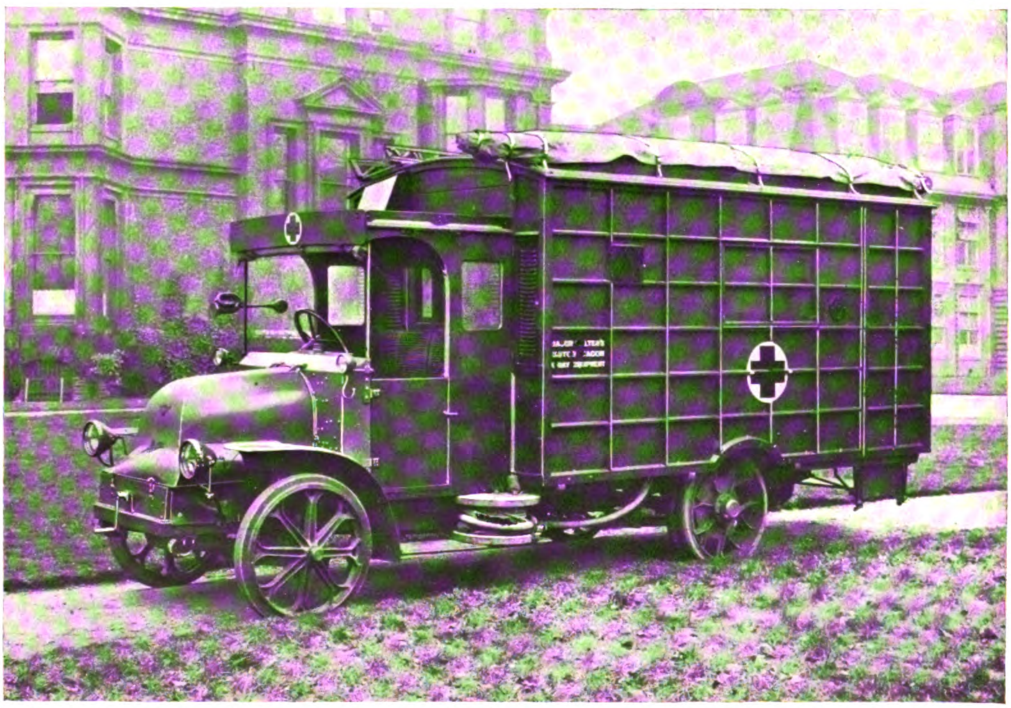

Fig. 2.—Exterior of Mobile X-Ray Unit.

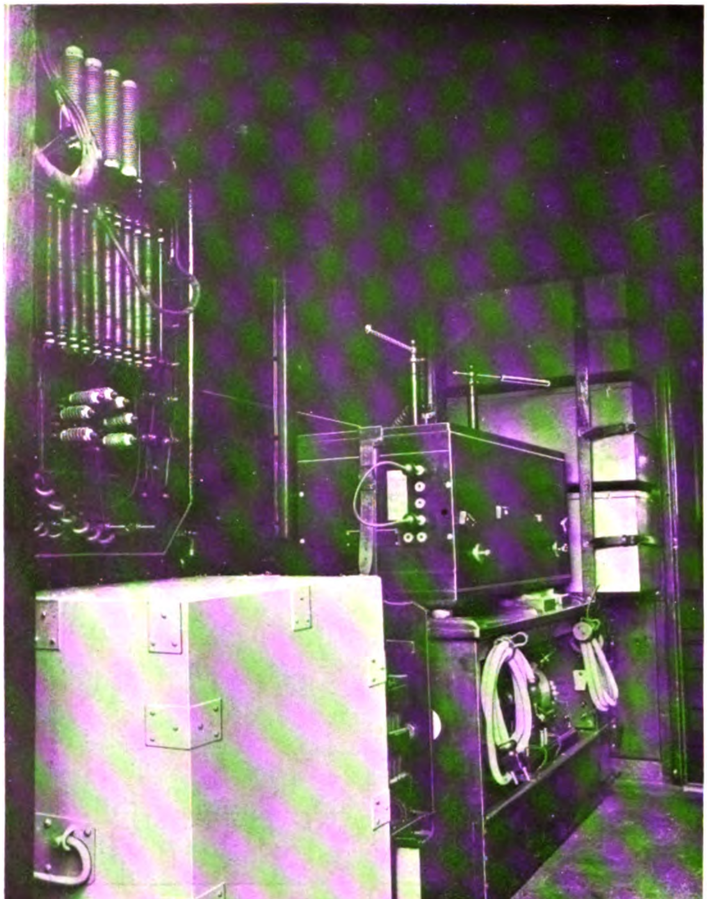
Fig. 5.—Interior, showing coil.

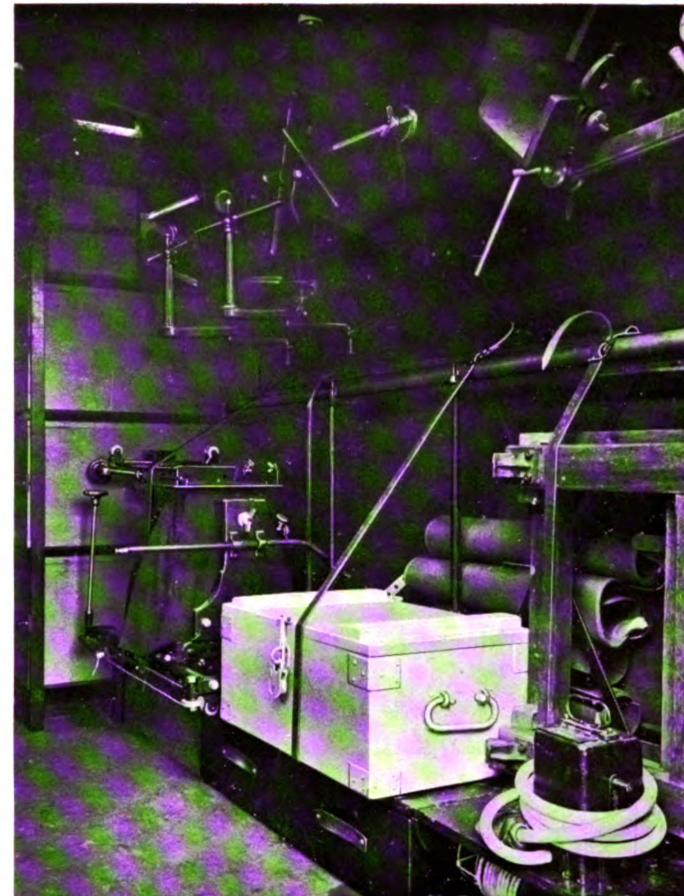
Fig. 6.—Interior, showing tables and accessories folded for transport.

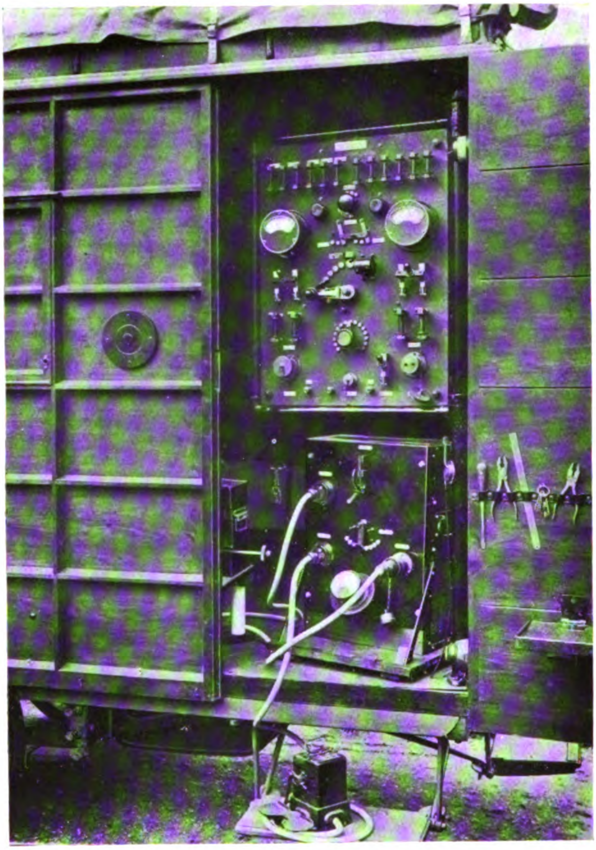

Fig. 7.—The Switchboard, revolved for operation from outside.

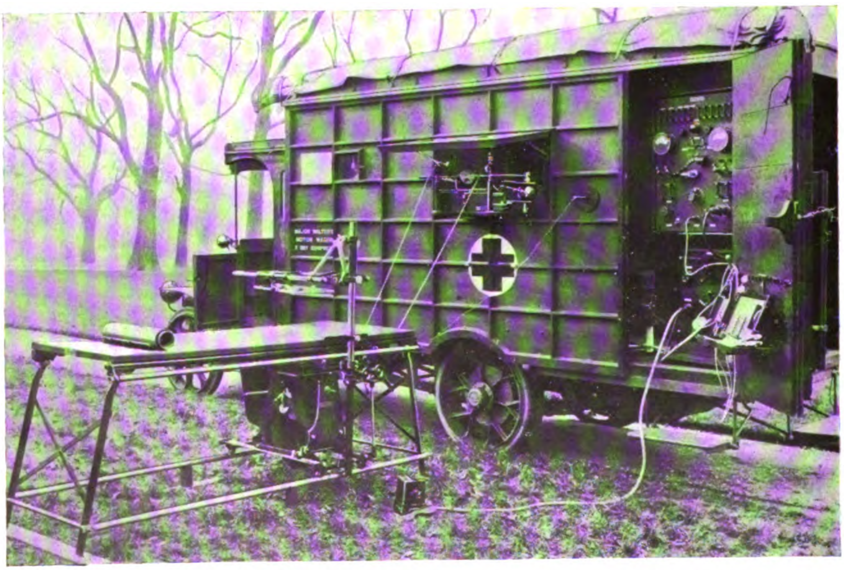

Fig. 8.—The table arranged for use, but without operating tent erected.

(5) **Qualification for Ordinary Membership.**—Candidates desirous of admission into the Society must have shown some scientific interest in the subjects within the purview of the Society. No person engaged in the practice of medical or surgical radiography shall be eligible for the membership unless he or she is proposed or seconded by a medical practitioner, who must have personal knowledge of the candidate. The final decision to rest with the Council. No person engaged in therapeutic work shall be eligible for the membership unless duly qualified in medicine. This rule shall not, however, exclude bona fide assistants to qualified practitioners, acting solely under their supervision; it also shall not be retrospective from the date of passing of these rules.

(6) **Proposal for Ordinary Membership.**—Every candidate for admission into the Society as an ordinary member, shall be proposed by one and seconded by another member of the Society, one of whom shall have personal knowledge of the candidate. The application for membership shall be made on an official nomination form, copies of which may be obtained from the Secretaries. The candidate shall undertake, by signing the nomination form, that in the event of his election to the Society, he will conform to the Rules of the Society, and further that he will pay the Annual Subscription to the Society and such other dues as may be imposed by the Society.

(7) **Election of Honorary Members.**—Honorary and Honorary Corresponding members shall be elected at any General Meeting of the Society, provided that the name of the proposed member has been submitted to the Society at its previous meeting.

(8) **Election of Ordinary Members.**—The name and qualifications of the proposed member shall be read before the Council at their next meeting, after the receipt of the nomination form. If approved by the Council the name shall be announced at the following General Meeting of the Society. Election shall be decided at the succeeding General Meeting by a show of hands unless a ballot be demanded, in which case one blackball in six shall exclude the candidate from election into the Society.

(9) **Notification of Election.**—When a candidate has been duly elected in accordance with Rule (8), notice to that effect shall be sent to him by the Treasurer together with a copy of the Rules of the Society and a request for the payment of the entrance fee and the subscription for the current financial year. If these fees be not paid within six months of the date of election, the matter shall be brought before the Council, who shall have power to declare the election void.

(10) **Privileges of Honorary and Honorary Corresponding Members.**—Honorary and Honorary Corresponding Members of the Society shall enjoy all privileges and benefits of ordinary members, but they shall not be required to pay the entrance fee or annual subscription.

(11) **Privileges of Ordinary Members.**—Every ordinary member shall be entitled

- (a) To attend, take part and vote at all General Meetings of the Society.
- (b) To receive a copy of each issue of the Journal of the Society, published during the time in respect of which subscriptions are paid.
- (c) To propose or second candidates for admission to the Society.
- (d) To use the Library or premises of the Society under the regulations which may from time to time be laid down by the Council.
- (e) To introduce visitors to each General Meeting of the Society.

(12) **Termination of Membership.**—Any members may resign from membership of the Society on written notification to the Secretary of his desire to do so.

Resignation will not be accepted unless all subscriptions due to the end of the current financial year have been paid, in respect of such member.

(13) **Expulsion from Membership.**

(a) Any member whose subscription is more than twelve months in arrears may be expelled frrom the Society by the decision of a majority of the Council. Any member so expelled shall be under legal obligation to pay the fees due up to the end of the financial year in which such action is taken.

(b) Any member of the Society, guilty of conduct which, in the opinion of the Council, renders him unfit for membership of the Society, may be expelled from the Society by unanimous decision of the members of the Council present at any duly called Council Meeting. In the event of incomplete agreement on the part of the Council the question may be referred to the following General Meeting of members, when a two-thirds majority shall entail expulsion from the Society of the member under consideration. The privileges of any member shall be suspended during such time as his expulsion is under discussion.

C. SUBSCRIPTIONS.

(14) **Entrance Fees.**—An entrance fee of one guinea shall be paid by all ordinary members on joining the Society.

(15) **Annual Subscription.**—The annual subscription to be paid by all ordinary members of the Society shall be one guinea.

(16) **Payment of Subscription.**—The annual subscription shall become due on the 1st January of each year, in respect of the following twelve calendar months, and must be paid to the Hon. Treasurer or such other official as may be deputed by the Council to act for this purpose. The date of subscription of members elected during November and December in any year to start from 1st January following.

(17) **Life Membership.**—Payment of a subscription of fifteen guineas at any time shall entitle a member to life membership. This shall not include the entrance fee, nor shall any reduction be made in respect of annual subscriptions already paid. The Council is empowered to elect to life membership without subscription.

D. ADMINISTRATION AND COUNCIL.

(18) **Management of the Society.**—The entire management of the Society is vested in the Council, in accordance with the rules herein laid down. It shall be the duty of the Council to administer these rules strictly and to enforce any penalties provided in cases of disregard of the regulations.

It shall be within the power of the Council to frame or repeal by-laws to provide for matters not dealt with herein, and the Council shall be the sole authority for the interpretation of such by-laws.

(19) **Composition of the Council.**—The Council shall consist of the following Officers and Members:—

(a) President.

(b) Past Presidents for the last three years.

(c) Vice-Presidents, not to exceed three in number.

(d) Honorary Treasurer.

(e) Two Honorary Secretaries.
(f) Two Honorary Editors of the Journal.
(g) Twelve ordinary members of the Council. Five members of the Council to form a quorum.

(20) **Election of Council.**—The Officers and Ordinary members of the Council, excepting Past-Presidents for the last three years, shall be elected at the Annual General Meeting by a majority of the members present at such meeting.

(a) The President shall retire annually and shall not ordinarily be eligible for re-election for the following session.
(b) The senior Vice-President shall retire each year, and shall not be eligible for re-election for the ensuing session.
(c) The Hon. Treasurer, Secretaries and Editors shall retire each year, but shall be eligible for re-election.
(d) Ordinary members of Council shall not serve longer than three years consecutively, the four senior members retiring each year.

All nominations for officers or members of Council shall be in the hands of the Secretaries twenty-one days prior to the Annual General Meeting, and in the hands of the members seven days before this meeting. Voting papers shall be provided if the number of nominations exceeds the number of vacancies to be filled. Two scrutineers shall be appointed at the meeting to count the votes.

(21) **Vacancies on Council.**—Any vacancies among officers or Council, which may occur during the session, shall be filled by the Council at their discretion.

(22) **Council Meetings.**—Meetings of the Council shall take place from time to time in order that the business of the Society may be adequately carried on.

(a) A Council Meeting shall be held monthly during the session of the Society. At these meetings nominations for membership shall be read, a monthly financial statement shall be submitted by the Hon. Treasurer and other business of the Society shall be transacted. The monthly meetings of the Council shall ordinarily be held immediately preceding the General Meetings of the Society.
(b) Special Council Meetings shall be called by the Secretaries at their discretion or at the request of four or more members of the Council. The ordinary business of the Society may be dealt with on such occasions, together with other matters of special importance, of which due notice has been given.

(23) **Chairmanship at Meetings.**—The President shall take the chair at all Council or General Meetings of the Society. In his absence the senior of the Vice-Presidents present shall officiate, or failing him, any officer or member shall be called upon to act as chairman. At all meetings the chairman may exercise a casting vote if necessary.

(24) **Minutes of Meetings.**—Duly recorded minutes of each Council Meeting shall be kept and these shall be read, and if approved, signed by the chairman at the next meeting of the Council.

E. GENERAL MEETINGS OF THE SOCIETY.

(25) **Ordinary General Meetings.**—Ordinary General Meetings of the Society shall be held each month from November to June, inclusive. The meetings shall ordinarily be held on the first Tuesday in the month. The date and time of such

meeting may be altered at the discretion of the Council, at least seven days' notice of such alteration being given.

(26) **Annual General Meeting.**—An Annual General Meeting of the Society shall be held during the month of June, for the following official business :—

- (a) To receive the report of the Council for the session ending at that meeting.
- (b) To receive the report of the Treasurer, with audited balance sheet of the Funds of the Society for the past financial year.
- (c) To elect officers and members of Council for the ensuing year.
- (d) To discuss any alteration of rules or other business which may be brought before the meeting in the manner laid down in these rules.

(27) **Special General Meetings.**—A Special General Meeting of the Society may be called by the Council at any time for the alteration of rules or for other special business. Such a meeting shall also be called on the written request of twelve ordinary members of the Society.

(28) **Convening of Meetings.**—Fourteen days' notice shall be given of the Annual General Meeting and of Special General Meetings, this notice must be accompanied by an agenda specifying all matters which are to be raised for discussion at the meeting referred to.

(29) **Quorum.**—Twelve members of the Society shall form a quorum at all General Meetings.

(30) **Minutes of Meetings.**—Minutes shall be kept of the proceedings at all meetings of the Society. These minutes shall be approved, and signed by the chairman at the next meeting.

F. FINANCES OF THE SOCIETY.

(31) **Financial Year.**—The financial year of the Society shall commence on the 1st January and shall end on the 31st December following.

(32) **Signature of Cheques.**—All cheques shall be signed by the Hon. Treasurer and one of the Hon. Secretaries conjointly.

(33) **Annual Audit.**—The Accounts of the Society shall be audited each year by a chartered accountant elected annually by the Society at each Annual Meeting as heretofore provided.

(34) **Investments.**—The surplus funds of the Society shall be invested in trustee securities as may be decided upon by the Council, after consultation with the Hon. Treasurer and a qualified accountant. All investments shall be registered in the name of the Public Trustee.

G. RULES.

(35) **Alteration of Rules.**—All alterations of the Rules of the Society must be dealt with at any Annual or Special General Meeting of the Society, of which due notice has been given in accordance with the foregoing paragraphs. Decisions shall be passed by a two-thirds majority of the members present at such meeting and shall be confirmed in like manner at a second business meeting before being carried into effect.

LIST OF MEMBERS, DEC. 1st, 1918.

C Denotes Members of Council (1917-1918).
* Denotes Life Members.

Elected.

9. 4.18 Aldridge, Norman E., M.B., C.M. (Edin.), 7, Cumberland Place, Southampton.

6.11.17 Allan, Dr. Carrick Allan, Hackney Infirmary, Homerton, E.9.

3.12.03 Allen, W., M.B., C.M., 20, Sandyford Place, Glasgow.

2. 1.17 Anderson, Miss A. I., B.Sc., 65, Abbey Road Mansions, St. John's Wood, N.W.8.

*4. 2.13 Andrews, Cuthbert, Esq., 47, Red Lion Street, Holborn, W.C.1.

1. 2.16 Ashwin, Miss Alice Maud, Waterloo Hill, Stratford-on-Avon.

9. 4.18 Aston, F. W., D.Sc., Chudleigh, Farnborough, Hants.

5. 2.18 Baker, Frank Leopold, 78, Swanston Street, Melbourne, Australia.

1. 2.98 Baker, F. W. Watson, F.R.M.S., 313, High Holborn, W.C.1.

4. 1.16 Baker, T. Thorne, F.C.S., 78A, Lexham Gardens, London, W.8.

7.11.11 Bailey, Charles Fred, M.D., 125, Marine Parade, Brighton.

3.12.12 Barclay, Alfred E., M.A., M.D., Kersal Bank, Kersal, Manchester.

1. 2.16 Barnard, J. E., Park View, Brondesbury Park, N.W.2.

1. 4.13 Barry, Thos. D. C., Lt.-Col., I.M.S., c/o Grindling & Co., 54, Parliament Street, S.W.1.

7.12.99 Batten, G. B., M.D., 2, Underhill Road, Lordship Lane, S.E.22. (*C.*) (*Vice-President.*)

4. 1.16 Beach, A. C. G., 64, Briscoe Buildings, Brixton Hill, S.W.2.

5. 5.14 Berry, Dr. Martin, Herbert Hospital, Woolwich.

4.11.09 Bird, E. Beverley, L.R.C.P., S.I., 15, Clarence Parade, Southsea, Hants.

4. 6.18 Black, D. Harold, 22, Newhall Street, Birmingham.

5. 5.14 Blake, G. G., A.I.E.E., 10, Onslow Road, Richmond.

2.12.13 Blackie, Alfred, M.A., 70, Claremont Road, Tunbridge Wells, Kent

4. 6.18 Bonnefoy, E., Villa Volta, Boulevard d'Alsace, Cannes (Alpes Maritimes), France.

7. 5.18 Bowes, Miss Phyllis Kessick, National Physical Laboratory, Teddington.

1. 1.18 Bowie, Capt., R.A.M.C., 3rd London General Hospital.

7. 1.19 Bowie, Eleazer R., New Orleans, Louisiana, United States.

— 6.99 Boys, C. V., F.R.S. (Honorary), 66, Victoria Street, S.W.1. (*Past President.*)

Elected.

7. 5.18 Brailsford, James Frederick, 19, Linden Road, Bearwood, Smethwick.

7. 1.19 Bridge, John William, West Kent Hospital, Brewer Street, Maidstone.

7.11.16 Brinkworth, J. Hancock, B.Sc., 31, Albert Mansions, Battersea Park, S.W.11.

9. 4.18 Brodsky, Gregory, Bailey's Hotel, Gloucester Road, S.W.7.

7. 3.07 Brown, Percy, B.A., M.D., Harvard, 155, Newbury Street, Boston, Mass., U.S.A.

10. 5.98 Buhl, Major F. J., 44, St. Aubyns, Hove, Sussex.

2.12.09 Bullimore, W. R., 61, Clerkenwell Road, E.C.1.

7.12.05 Burnside, Evelyn E., Esq., 9, Clifton Road, Crouch End.

3. 4.17 Burrows, Arthur, M.D., Radium Dept., Royal Infirmary, Manchester.

7.12.99 Butcher, W. Deane, M.R.C.S., Holyrood, Cleveland Road, Ealing, W.13. (*Past President.*)

6.11.17 Butler, Lady Constance Mary, 32, Upper Brook Street, W.1.

3.12.12 Bythell, W. J. Storey, B.A (Cantab), M.D., Beech Hill, Singleton Road, Kersal, Manchester.

4. 4.16 Caldwell, J. R., M.B., C.H.B., Fargo Hospital, Salisbury Plain.

*7.12.15 Caulfield, A. St. George, Vicars Hill, Lymington, Hants.

1. 2.06 Chambers, W. D. F., B.A. (Cantab.), 90, Gordon Road, Ealing, W.13.

7.11.16 Channon, H. C., M.I.E.E., 18, Wharf Road, City Road, N.1.

3. 5.00 Chaplin, A., "The Firs," Crowhurst, Sussex.

19.12.17 Clark, Jeremiah Simpson, M.D., B.A., C.A.M.C., Canadian General Hospital, Shorncliffe.

18. 4.01 Clarke, Chas. Alex., L.D.S., 42, Welbeck Street, W.1. (*C.*)

4. 6.18 Clements, Francis Victor, Military Hospital, Bagthorpe, Notts.

Cocks, Ernest T., 34, Briarwood Road, Clapham Park, S.W.

*5.12.16 Codd, Mortimer A., 32, Half Moon Lane, Herne Hill, S.E.24.

9. 4.18 Coglin, Capt. William Alexander, C.A.M.C., No. XI. Canadian General Hospital, Shorncliffe.

3. 3.96 Coldwell, W. A., 6, Mandeville Place, Manchester Square, W.1.

19.12.17 Comrie, John, M.D., F.R.C.P.Ed., 25, Manor Place, Edinburgh.

19.12.17 Conklin, John Henry, M.D., C.A.M.C., No. 12 General Hospital, Bramshotts, Hants.

5. 3.08 Connor, Lt.-Col. F. Powell, F.R.C.S., c/o A.D.M.S. Base, M.E.F. (D), Basra.

7.12.15 Cookson, F. Nesfield, M.D. (Lond.) F.R.C.P. Eng., Taggscroft, Stafford.

1897 Cotton, W., M.D., 231, Gloucester Road, Bishopston, Bristol.

Elected.	
17. 6.99	Crane, A. W., M.D., 420, Rose Street, Kalamazoo, Michigan, U.S.A.
1897	Crookes, Sir W., O.M., F.R.S. (Honorary), 7, Kensington Park Gardens, Notting Hill, W.11.
5. 3.18	Crossley, Emily Helen, No. 1 Canadian General Hospital, Étaples, France.
19.12.17	Crymble, Percival Templeton, M.B., B.Ch., R.U.L., F.R.C.S.Eng., 7, Upper Crescent, Belfast.
2. 3.05	Cumberbatch, Elkin Percy, M.A., Oxon, B.M., M.R.C.P., 15, Upper Wimpole Street, W.1.
19.12.17	Curtis, Wilfred, M.D., C.A.M.C., No. 2 Canadian Stationary Hospital, B.E.F., France.
6. 2.17	D'Albe, E. E. Fournier, D.Sc.(Lond., Birm.), A.R.C.Sc., M.R.I.A., Binbrook, East Moseley, Surrey.
3.12.12	Darling, Byron C., B.A., M.D., Harvard, 122, East 34th Street, New York City.
— 1897	Davidson, Sir James Mackenzie, M.B., 26, Park Crescent, Portland Place, W.1. (*Past President*).
1. 6.11	Dean, Alfred, Leigh Place, Hatton Garden, E.C.1.
19.12.17	Dight, Capt. Wilfred Bittingsley, M.B., University Club, Castlereagh Street, Sydney, N.S.W.
20. 4.15	Dineen, George P., "Royston," 108, London Road, Wembley.
6.12.00	Dodd, John, M.D., 14, King Street, New Walk Gate, Leicester.
7. 5.18	Donnelly, Miss Winifred E., National Physical Laboratory, Teddington.
20. 4.15	Donnithorne, H.E., 8, Crescent Road, Wimbledon.
7. 1.19	Doran, F. E., Royal Infirmary, Manchester.
5. 3.08	Doyle, A. A., F.R.C.S.I., Union Trustee Chambers, Brisbane, Queensland.
9. 4.18	Dunbury, Capt. James, M.D., C.A.M.C., No. XI. Canadian General Hospital, Shorncliffe.
2. 5.16	Dutton, John Rowe, Military Hospital, Sutton Veny, Wilts.
4. 4.16	Eagar, Dr. W. H., Capt. C.A.M.C., X-Ray Dept., Granville Canadian Special Hospital, Buxton, Derby.
2. 3.15	Eccles, Herbert Annesley, M.D.Lond., M.R.C.S., L.R.C.P., 97, Church Road, Upper Norwood, S.E.19.
4. 6.18	Eden, Charles Wm., 32, Lucknow Avenue, Nottingham.
7. 1.19	Edwards, David Richard, Swansea Hospital, 84, King Edward Road, Swansea.
5. 2.18	Edwards, James George, M.B., M.S., 279, Macquarie Street, Sydney, Australia.
6.11.17	Ellis, Dr. E. Erasmus, 46, High Street, Beira, Johannesburg, S. Africa.
2. 2.11	Ensor, George E., Assoc. I.E.E., Pretoria Dist. Hospital, South Africa, Box 201.

Elected.	
1. 1.18	Felgate, Russell Soden, Briardene, Northwood, Middlesex.
5. 1.11	Finzi, Samuel Neville, M.B., 107, Harley Street, W.1. (*C*)
1. 6.15	Fleck, Alexander, B.Sc., The Castner-Kellner Alkali Co., Wallsend-on-Tyne.
2.12.13	Forder, A. O., 55, Playfield Crescent, East Dulwich, S.E.22.
1. 1.18	Forsyth, Leslie M., No. 1 South African General Hospital, Abbeville, A.P.O., S.1, B.E.F.
3. 1.01	Foster, W. J., F.R.C.S., "Downs," 11, Bath Road, Reading.
5. 1.13	Fowler, Frank, M.D., 29, Poole Road, Bournemouth.
4. 6.12	Fowler, Wm. Hope, M.B., 21, Walker Street, Edinburgh.
*11. 1.98	Frost, Edmund, M.D., "Chesterfield," Chesterfield Road, Eastbourne.
19.12.17	Fry, Capt. Kelsey, M.B., L.D.S., M.C., The Queen's Hospital, Sidcup, Kent.
7.12.05	Fryett, A. G., F.R.M.S., Holmhurst, Beacon Road, Hither Green, S.E.13.
1. 5.17	Gage, H. C., Alma House, Rayne Road Braintree, Essex.
2. 1.17	Gaitskell, H. A., M.D., M.B., B.C.(Cantab), M.A., Harrow, Hamlet Court Road, Westcliffe-on-Sea.
3. 7.02	Gamlen, H.E., M.B., B.S., D.P.H., Chadwick House, York Road, West Hartlepool.
1897	Gardiner, J. H., F.C.S., 59, Wroughton Road, Balham, S.W.1. (*C*) (*Past President*.)
6. 3.17	Gee, Harry Thomas Page, 70, George Street, Croydon, Surrey.
19.12.17	Geddes, A. M., Glencairn, Grove Avenue, Claremont, Cape Colony, S. Africa.
4. 1.16	George, H. Trevelyan, M.A., M.R.C.S., 33, Ampthill Square, N.W.1.
7. 1.19	Gibson, Capt. K. J., Research Department, Royal Arsenal, Woolwich.
97	Gifford, J. W., F.R.A.S., F.R.M.S., Chard, Somerset.
1. 5.17	Gilchrist, Capt. L., Ontario Military Hospital, Orpington, Kent.
9. 4.18	Gills, Capt. George Luther, M.D., C.A.M.C., C.A.M.C. Depot, Shorncliffe.
	Glasson, Capt. C. J., Netley, Hants.
1. 1.18	Goldsmith, John Naish, Ph.D., M.Sc., 67, Chancery Lane.
6.10.99	His Highness Sir Bhagvat Singh, The Thakore Sahib of Gondal, c/o H. S. King & Co., 45, Pall Mall, S.W.1.
5. 5.14	Gould, Sir A. Pearce, K.C.V.O., 10, Queen Anne Street, W.1. (*Past President*.)
	Greatbatch, A., Esq., B.Sc., 40, Rochdale Road, Plumstead.
7.11.16	Green, Dr. Russell A., 86, Hagley Road, Birmingham.
9. 4.18	Griffiths, Capt. H. E., R.A.M.C., M.R.C.S.Ed., M.R.C.S., L.R.C.P., 11 General Hospital, Italian Expeditionary Force, V.G.
4. 6.18	Gudgeon, A. J., 2, Norfolk Square, Brighton.

Elected.

4. 3.13 Gunstone, Arthur C., 33, Newton Street, High Holborn.

1. 1.18 Guttentag, Wilfred E., 4, Clement's Inn, W.C.2.

4. 6.18 Haddow, Capt. A. C., R.A.M.C., No. 6, Mobile X-Ray Unit, Attached to 57 C.C.S. Home address: Armley, Leeds.

2. 6.10 Hall-Edwards, J., L.R.C.P., L.M.Edin., 103, Newhall Street, Birmingham. (*Vice-President.*)

1. 6.15 Hallam, Arthur Rupert, M.D., 305, Glossop Road, Sheffield.

2.12.09 Hampson, Wm., M.A., L.M.S.S.A., 8, West Chapel Street, Down Street, W.1. (*C.*)

7. 7.00 Hancock, William J., Weld Club, Perth, Western Australia.

5. 1.14 Hardman, Harwood Freak, M.D., 1, The Avenue, Eastbourne.

7.11.16 Harlow, F. J., St. Nicholas, Castlebar Park Road, Ealing, W.5.

7.12.99 Harris, L. H. L., M.B., 215, Macquarie Street, Sydney, N.S.W.

5. 1.14 Harvey, John Owen, M.D. Lond., 33, Camden House Road, Kensington, W.8.

9. 4.18 Hawk, Capt. Francis Swanston, I.I.A., R.A.M.C., 169, York Road, Worthing, Surrey.

6 12.06 Hazleton, E. B., M.D., 213, Wimborne Road, Bournemouth.

6. 6.07 Head, Howard C., 21, Broxholm Road, West Norwood, S.E.27. (*C.*)

4. 4.16 Heath, F. H. R., 22, Abbotsbury Road, Weymouth.

7.11.11 Hernaman-Johnson, Francis, M.B., etc., 33, Cavendish Square, W.

2.12.13 Higgins, W. F., B.Sc., Somerset Lodge, The Avenue, St. Margaret's-on-Thames. (*Editor of Journal*). (*C.*)

4. 6.18 Hird, Alfred Ernest Wilson, Surgeon, R.N.V.R., H.M.R.N. Hospital, Granton.

19.12.17 Hitchcock, Charles, M.R.C.S., L.R.C.P., Officers' Quarters, British Red Cross Hospital, Netley.

4. 6.18 Hoghton, Capt. Eric Aloysius, R.A.F., Foxwarren Park, Cobham, Surrey.

1898 Holland, C. Thurstan, M.R.C.S., L.R.C.P., 43, Rodney Street, Liverpool. (*Past President.*)

5.12.16 Holland, Charles E., 12, Redington Road, Hampstead, N.W.1.

9. 4.18 Hope, Percy Lake, M.R.C.S., L.R.C.P., Capt. R.A.M.C., Westdean, Queen's Road, Worthing.

1 1.18 Howard, Dr. J. A., Clifton House, Church Road, Upper Norwood.

5. 2.18 Howden, Ian, M.D. (Edin.), F.R.C.S (Edin.), 6, Cambridge Terrace, Dover. Temp. address: No. 14 Mobile X-Ray Unit, B.E.F., France.

7.11.11 Hugo, Dr. D. Del, M.B., C.M., Mansion House Chambers, Cape Town, S.A.

3.12.12 Humphris, Howard, M.D., 8, West Chapel Street, Mayfair, W.1.

5. 3.18 Hunt, Graham, 6, Park Crescent, Torquay.

3.12.12 Hutchinson, Donald H., M.D., St. Annes, Gordon Road, Lowestoft.

4. 4.16 Hutton, E. W., d'Hyvreuse Lodge, Cambridge Park, Guernsey.

4. 6.18 Ilseey, Geo. Robert, 40, Woodland Rise, Muswell Hill, N.

1. 2.98 Ince, Francis, The Hermitage, Jarvis Brook, Sussex.

5.99 Jackson, Professor Sir Herbert, F.R.S. (Honorary), King's College, Strand, W.C.2, and 49, Lansdowne Road, W.11. (*Past President.*)

6. 4.05 Jacob, F. H., M.D., M.R.C.P., 32, Regent Street, Nottingham.

6.15 Jeffries, J. Finbar, 71, Esselen Road, Sunnyside, Pretoria.

19.12.17 Johnson, Henry M., M.B., F.R.C.S., Lt. R.A.M.C., The Queen's Hospital, Sidcup, Kent.

5. 5.14 Jolly, W., 43, Paddington Street, Baker Street, W.1.

7.12.15 Jones, W. J., 6, St. Thomas Gardens, Havestock Hill, N.W.3.

3.10.10 Judah, D., L.M.S., Bombay, M.B., B.S., (Lond.), Lansdowne House, Apollo Bunder, Fort No. 1, Bombay, India.

4. 2.13 Kaye, G. W. C., M.A., D.Sc., 76, Addison Gardens, Kensington, W.14. (*President.*)

2. 1.17 Keen, Capt. E. B., L.M.S.S.A., 128, Fulham Road, South Kensington, S.W.3.

3. 2.13 Kempster, C. R., M.R.C.S., 1, Harley Street, W.1.

1. 1.18 Kennedy, Ralph William, 31, Gartmoor Gardens, Wimbledon Park Road, S.W.19.

10. 1.99 Kent, H. A., The Poplars, Maidstone Road, Bounds Green, N.11.

5. 6.17 Kent, Philip Charles, 2, Fordhook Avenue, Ealing Common, W.5.

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7.12.99 Killik, Arthur, Elveden, Esher. (*Vice-President.*)

6. 2.17 Kingsbury, Wm. Neave, M.R.C.S., L.R.C.P., Electro-Therapeutic Department, Middlesex Hospital, W.1.

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3 3.14 Leatham, Henry Blackburn, M.R.C.S., L.R.C.P., New Plymouth, New Zealand.

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20. 4.15 Morphy, B. H., 159, Great Portland Street, W.1.

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6. 2.17 Morrow, David, M.R.C.S., L.R.C.P.(Lond.), L.S.A., Woodhurst, Old Park Road, Palmer's Green, N.22.

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9. 4 18 Muir, John Keir, M.R.C.S., Capt. R.A.M.C., 62 General Hospital, Italy.

6. 2.17 Musson, Major George, C.A.M.C., Military Hospital, Shorncliffe.

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3. 5.00 Newcastle, His Grace The Duke of, 11, Hill Street, Berkeley Square, W.1.

7. 4.14 Nicholson, J. W., M.A., D.Sc., F.R.S., Professor of Mathematics, King's College, Strand, W.C.2. (*C.*)

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4\. 3.09 Notcutt, S. A., B.A., B.Sc., Constitution Hill, Ipswich.

6.12.06 Nutt W. Harwood, M.D., 280, Western Bank, Sheffield.

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1897 Phillips, Major, C. E. S., F.R.S.E., 54, Bedford Gardens, London, W.8. (*Past President.*)

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5\. 2.18 Robertson, Evie A., M.B., Ch.B., Hackney Infirmary, Homerton, E.9.

1\. 2.00 Rodman, G. H., M.D., 4, Heath Mansions, Putney Heath, S.W.15. (*C.*) (*Past President*).

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1\. 1.03 Stoney, Miss Florence Ada, M.D., B.S.Lond., 29, Nottingham Place, W.1.

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5\. 2.18 Trainer, James Patrick, Ocean House, Moore Street, Sydney, Australia.

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ABSTRACTS.

682. *Absorption of the Radiation emitted by a Palladium Antikathode in Rhodium, Palladium and Silver.* E. A. OWEN. (Roy. Soc., Proc. 94. pp. 339-352, May 1, 1918.)—A preliminary account is given of some experiments carried out with the rays from an ordinary X-ray bulb. A spectrum of the rays from a Pd antikathode is obtained over a limited range of wave-lengths by reflection in the (III) face of a carborundum crystal. The spectrum shows that the bulb emits a continuous band of wave-lengths upon which are superposed the characteristic rays of the metal of the antikathode, and, under the conditions of working in this particular case, the relative intensities of the different wave-lengths in the spectrum remain approximately constant.

There is a minimum of intensity in the spectrum corresponding to the wave-length $0{\cdot}493 \times 10^{-8}$ cm. On the assumption that the minimum is due to the selective absorption of this wave-length in the crystal, the value $0{\cdot}493 \times 10^{-8}$ cm. is assigned to the β-line of the J-series of silicon. From the experimental results of Barkla and White (Abs. 166 (1918)) on the J-series of the elements Al, C and O, the approximate values deduced for the β-line of the J-series of oxygen and carbon are $0{\cdot}519 \times 10^{-8}$ cm. and $0{\cdot}559 \times 10^{-8}$ cm. respectively.

Assuming Bragg's mean value of the α-line of palladium to be $0{\cdot}586 \times 10^{-8}$ cm. the following values are obtained for the wave-lengths of the β- and γ-lines : $\beta = 0{\cdot}520 \times 10^{-8}$, $\gamma = 0{\cdot}509 \times 10^{-8}$ cm. The absorption coefficients of the rays from the bulb have been measured in rhodium, palladium and silver. The results show that the connection between wave-length and absorption coefficient is expressed by the relation $\tau/\rho = K\lambda^3$, where $\tau\rho$ is the fluorescent coefficient and K is a constant for a given substance over a range of wave-lengths between the absorption bands of that substance.

The critical wave-length necessary to excite the characteristic rays of a substance, lies in the neighbourhood of the β-ray of that substance. The α-ray is not excited until the β-ray is excited. It is pointed out that the purity of the characteristic lines emitted by a bulb and isolated by reflection at a crystal face will depend to a certain extent upon the working of the bulb. A. B. W.

773. *Sensitometry or Röntgenographic Materials.* M. B. HODGSON. (Am. J. Röntgenology, p. 610, 1917. Frank. Inst., J. 185, pp. 557-559, April, 1918. Comm. No. 63 from the Research Lab. of the Eastman Kodak Co.)—The chief obstacle to making accurate sensitometer exposures to X-rays lies in the difficulty of making consecutive exposures accurately. In white light and sensitometry, a simple rotating opaque sectored disc, with the openings proportional to the progression of exposures, may be interposed between the light-source and the plate, and a series of exposures obtained simply and accurately. With the available Röntgen equipment such procedure is impossible. The current furnished to operate the tube efficiently is pulsating, with the max. frequency usually 60 cycles per sec. Therefore, by interposing the rotating sectored disc in front of the tube operated by such pulsating current more or less synchronism occurs and grave errors follow. The most feasible method of working is to move the plate itself to intermittent motion across the path of the X-ray beam in such manner that a known progression of exposures is given, controlled to the desired accuracy. In the sensitometer adopted for the present work, the photographic plate is moved in this manner, the length of the exposure steps being controlled by an actuating electromagnetic mechanism. For the study of Röntgen emulsions it was found most convenient to use an exposure progression of consecutive powers of $\sqrt{2}$. The Röntgen-tube circuit was connected to a solenoid switch, this switch being operated at the proper time by the sensitometer mechanism. The entire operation of exposure was thus governed to within an error of 3 per cent. In plotting the density values of the resultant exposure strips, no absolute values are assigned to the points along the abscissæ, the curve being located merely by the known progression of exposures given assuming an arbitrary exposure unit. The type of curve is somewhat different from that usually obtained from white-light exposure. The

max. density is beyond any which is optically measurable even with the most intense light-source, the curve sweeping in a close approximation to a parabola, until a density of 5·0 or more is reached. For average Röntgenographic research, however, the portion of the curve to be considered is only that limited by such a density as can be seen through the average viewing frame. This is a density of about 2·5. The method has been applied for the study of variation in the photographic effect of varying hardnesses or wave-lengths of X-rays. With the present types of X-ray emulsions the characteristic density-exposure curve has been found to increase in slope or contrast with the softness of the tube, that is, with an increase in wave-length. The rendering power of the plate from these latter curves has been found to depend both upon the plate itself and the tube hardness. The method presents an accurate means for the measurement of intensifying-screen efficiency.

A. E. G.

800. *Elimination of Secondary Radiation in Radiography—The Antidiffuser.* TAULEIGNE and G. MAZO. (Archives d'Él. Médicale, 26 pp. 160-163, April, 1918.)—Distinct radiographs of the thicker parts of the body are very difficult to obtain owing to the amount of secondary radiation which occurs. The apparatus here described has been designed with the idea of cutting out the effects of this secondary radiation and so enabling radiographs of the body to be obtained comparable in definition with those of the hand, etc. It consists essentially of a chassis moved by clockwork upon rails, under which the photographic plate is introduced, the subject to be radiographed being placed upon a board, covering the chassis. The plate and subject remain at rest, the chassis only being movable. The action of the secondary radiation is annulled by thin sheets of lead suitably placed in the chassis. The method of using the antidiffuser is described, and diagrams illustrating its construction are given. It is claimed that radiographs taken with the aid of this appliance, using screens and hard radiations, and without undue narrowing of the image, give entire satisfaction tn photographer, radiographer, and surgeon alike.

A. E. G.

845. *Resolving Powers of X-ray Spectrometers, and the Tungsten X-ray Spectrum.* E. DERSHEM. (Nat. Acad. Sci., Proc. 4, pp. 62-65, March, 1918.)—From simple considerations of crystal reflection the author shows that the resolving power of a given crystal may be expressed as follows :—

$$\lambda/\Delta\lambda < nr\lambda/[d \cos\theta \ (s+2t \cos\theta)],$$

where λ is wave-length of X-radiation reflected at the angle θ, d the "grating space" of the crystal, s the width of the X-ray beam, t the thickness of the crystal, and n the order of the spectrum.

From this expression it appears that the resolving power may be increased by increasing the order of the spectrum and the distance between the crystal and the photographic plate, and also by decreasing the width of the source and the thickness of the crystal. To increase the resolving power by any of these means results in a loss of intensity which must be compensated for by an increased time of exposure.

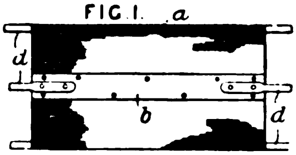
Using a Coolidge tube, with tungsten target, and reflecting from a rock-salt crystal the author has made a series of careful measurements of the wave-lengths in the X-ray spectrum of tungsten. The results, which are tabulated, are claimed to be accurate within 0·1 per cent. in the case of L-radiations and 0·8 per cent. in the case of K-radiations. In the case of the L-lines the resolving power, as defined above, was less than 170, but nevertheless 19 separate and distinct lines were obtained. A. B. W.

Abridgments of recent Patent Specifications bearing upon the subject of X-rays and Allied Phenomena.—Compiled for publication by H. T. P. GEE, *Patent Agent, Associate I.E.E.,* 25, *Victoria Street, Westminster, London, S.W.*1, *and at* 70, *George Street, Croydon.*

114,968. *Vacuum Tubes.* OSRAM-ROBERTSON LAMP WORKS, LTD., and DURDLE, O., Brook Green, Hammersmith, London. Sept. 11, 1917.—The anode of a valve or other tube for

use in wireless telegraphy, etc., is made of a single layer of cloth closely woven from fine wire of a refractory metal such as tungsten, molybdenum, or an alloy. A cylinder may be formed by

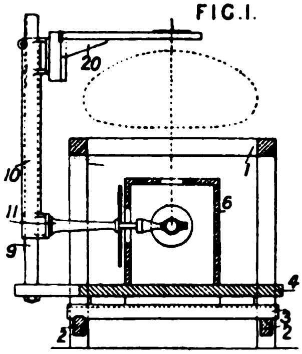
FIG. I.



bending one or more pieces *a* of such cloth and joining the edges by riveting them to longitudinal strips *b* attached to pairs of carrier bars *d*, all these parts being preferably of the same metal.

115,251. *Röntgen-ray Apparatus.* DAVIDSON, J. M., 26, Park Crescent, Portland Place, London. March 26, 1917.—In X-ray localization apparatus, the X-ray tube, the fluorescent screen, and the cross-wires or the like are mounted in fixed relationship to each other, the whole being adjustable along the line through the cross-wires and the anti-cathode centre, and also, so that two shadows of the foreign body may be obtained, parallel to the screen, means being provided by which the depth of the foreign body may be determined from the displacement of the shadows; means for marking the spot upon the patient's skin beneath which the foreign body is situated, for measuring the distance of this spot from the cross-wires, and a stop-plate with a variable aperture for adjusting the diameter of the beam may also be provided. As shown in Fig. 1, the tube is movably mounted within a protective box 6, and is supported by an arm 11 secured to a sleeve 10 which carries a pivoted frame 20 supporting the screen and cross-wires. The sleeve 10 is adjustable vertically by rack and pinion upon an upright 9 secured to a carriage

FIG. I.



4 movable transversely on a carriage 3 which travels longitudinally on rails 2 carried by the table 1 upon which the patient is laid. The apparatus is displaced longitudinally to obtain the two shadows. In a modified construction, Fig. 3, the longitudinal and transverse adjustments are similarly effected, but the tube, etc., is displaced transversely to obtain the two shadows. The tube engaging an upright piece 19 carried by the carriage 4, The screen, etc., is carried by an upright 10 secured to the box, and vertical adjustment is obtained by moving the slider 15 horizontally. The tube, screen, etc., may, in a further modification, be carried by a stand 23, Fig. 5, mounted on castors, the stand being capable of being fixed relatively to the floor by means of two pins 39 which are lowered so as to touch the floor by springs 40 when nuts 42 on their screwed upper parts are turned simultaneously by means of a connecting-cable 44 and a handle 45. The tube box 6 may be hingedly supported on an arm 24 and be secured in any position by a screw clamp 38. The arm 24 is slidably mounted in a sleeve 25 which is itself slidable in a casting 26 vertically adjustable on a vertical tube 27, by a rack 28 and a pinion operated by a handle 29, the casting 26 being attached to a counterweight within the tube 27 by a wire 30 passing over a pulley 31. Fine adjustments for the position of the sleeve is clamped between upper and lower parts 5, 6 respectively of the protective box, and the box is supported by four inclined surfaces 18 upon inclined surfaces 17 carried by a slider 15, one end of the box 25 and the angular position of the casting 26 about the axis of the tube 27 are provided. Displacement of the tube,

etc., through a known distance to obtain a second shadow is effected automatically in this modification by means of a lever 46 which is pivoted on a ring 49 and has a pin 52 at one end moving in vertical slots 53 under the control of a spring, the ring 49, when the lever is moved, coming into engagement with the end of the sleeve 25 and limiting the movement. The cross-wires may comprise two parallel wires W1, W2, Fig. 8, separated by a distance equal to that through which the tube is moved, which are intersected at right-angles by a single wire W and mounted in a frame 56, slidable in the frame 20 by means of a rack and a pinion operated by a wheel 59 having a graduated edge. The first shadow of the object is arranged to fall on the wire W_1, and, after displacement of the apparatus, the wheel 59 is turned to bring the second shadow P_2 on to the wire W_2, the depth of the object from the cross-wires being read off from the wheel 59. A scale in fixed relation to the cross-wires giving a direct reading of the depth of the foreign body therefrom may be provided, either as a scale on celluloid or glass on the upper part of the

FIG. 3.

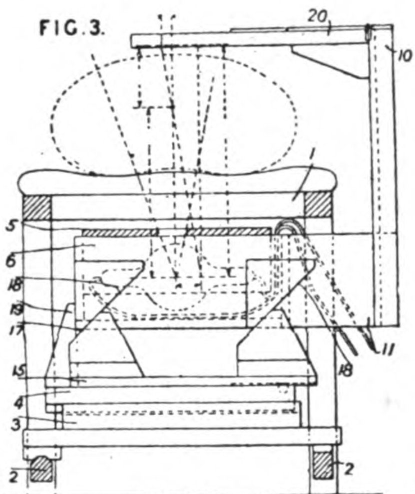


FIG. 5.

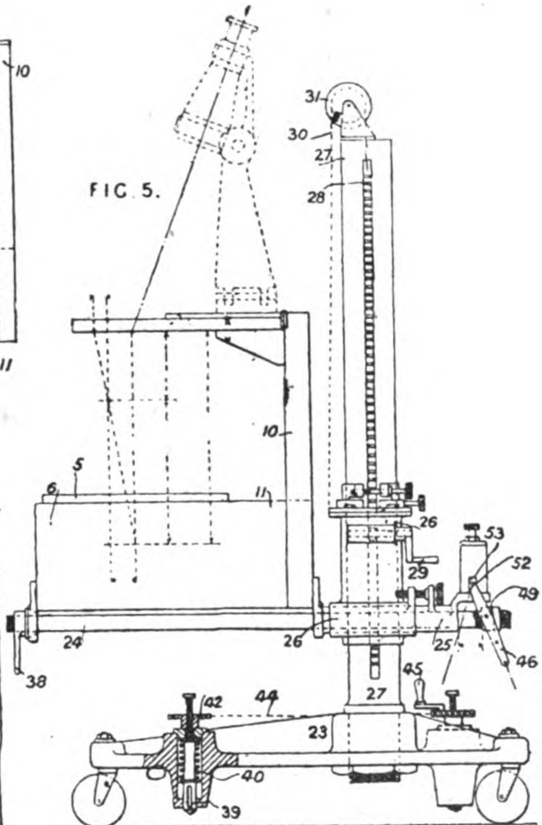


FIG. 8.

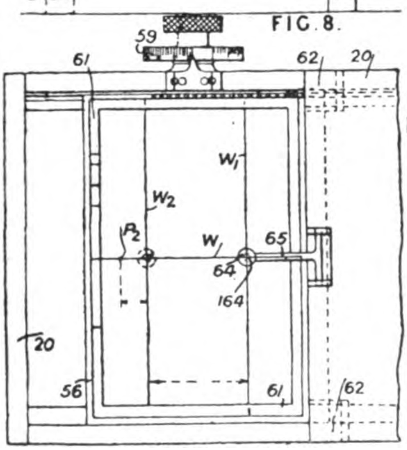
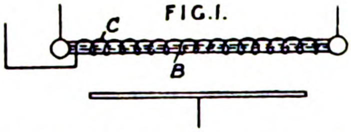


FIG. 10.

screen, or as a scale formed by notching or perforating the cross-wires themselves. The screen is carried in a frame 61 mounted on the frame 20 by double hinges 62. The spot on the patient's skin beneath which the foreign body is situated may be marked by the point of a rod 164 which is graduated to enable the depth of the spot from the cross-wires to be read and is mounted in a casting 64 which is hinged and provided with a stop arm 65 so that it may be turned into proper position when the screen frame 61 is swung out of the cross-wire frame 56. The top of the protective box may be provided with a slidable plate 66, Fig. 10, having a large aperture registering with an elongated aperture in the top of the box, and having also a number of pivoted stops 67, 68, 69 of various sizes which may be used to vary the diameter of the beam and a pivoted plate 70 by which the beam may be entirely cut off. As indicated in Fig. 5, 'a pair of binocular magnifying-glasses may be mounted above the frame 20 so that the shadows may be observed from one side.

115,700. *Electric Vacuum Tubes.* BROWN, S.G., Edward Road, Willesden Lane, North Acton, London. May 18, 1917.—In an electric relay, amplifier, or detector, a "grid" electrode is placed in direct contact with an emitting oxide coating on the hot cathode. As shown, the

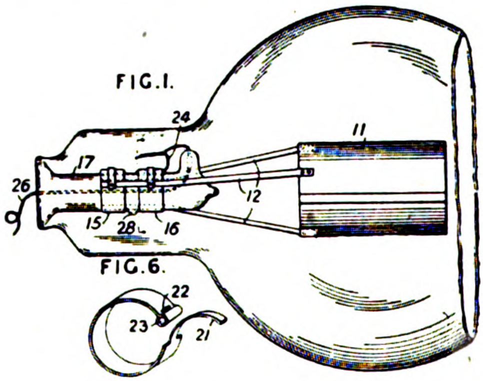
FIG. I.



grid consists of a wire C wound on the coating B. The wire may be partly or wholly embedded in the oxide; in the latter case, the anode may also be placed in contact with the coating, for instance by being wound thereon in the form of wire. An additional separate anode for collecting stray ions may then be provided.

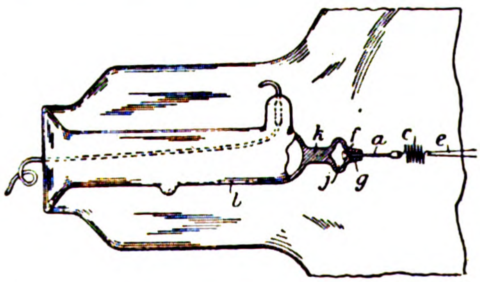
116,133. *Vacuum Tubes.* OSRAM-ROBERTSON LAMP WORKS and DRIVER, F. P., Brook Green, Hammersmith, London. May 29, 1917.—Means for supporting an anode or grid, particularly in a high-power tube used in wireless telegraphy, comprises a metal clip encircling a re-entrant tubular part of the container and connected by arms 12, Fig. 1, preferably three in number, to the electrode. The cylindrical anode 11 shown is supported by two such clips 15, 16 attached to the same arms 12 and held in place by a protuberance 28 on the re-entrant tube 17

FIG. I.



between the clips. Each clip consists of a metal band provided with a tongue 21, Fig. 6, and a slot 22, beyond which is a roll 23 to prevent breakage of the tongue when this is bent back after insertion in the slot. In the roll of one clip may be soldered the conductor 24, which may be attached to a wire 26 sealed in the side or end of the re-entrant tube, or may be sealed through the side of the container. The arms 12 are preferably of V section. The grid, which may consist of a wire coiled around parallel straight wires attached to arms, may be supported by another re-entrant tube or the anode may be supported as described from both ends, the grid being otherwise held, for instance, as described in Specification 116,135.

116,134. *Vacuum Tubes.* OSRAM-ROBERTSON LAMP WORKS and HARVEY, C. H., Brook Green, Hammersmith, London. May 29, 1917.—In a tube such as is used in wireless telegraphy, a coiled spring *c* maintaining a filament *e* in tension is attached to a pin *a* which is in alinement with the filament and the axis of the spring and is retained loosely within a guide by a head on

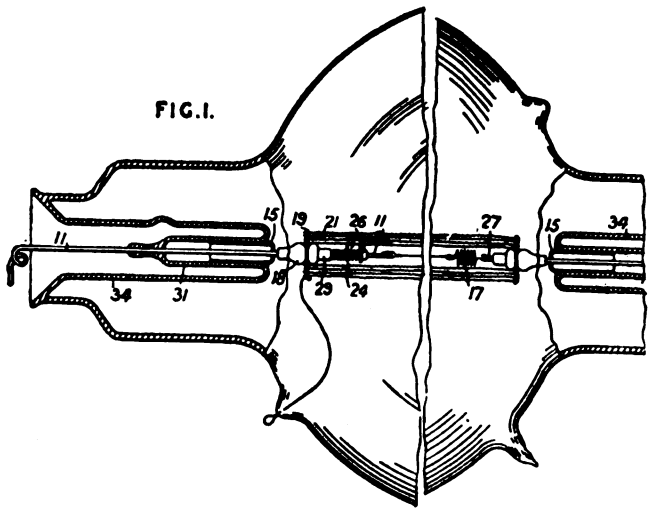


the pin. The guide permits thermal expansion of the pin while preventing lateral displacement beyond small limits. In the arrangement shown, the pin is inserted in a socket *g* opening into an

enlargement *j*, which receives the head *f* of the pin. The socket is attached by a stem *k* to the inner end of a re-entrant tube *l*.

116,135. *Vacuum Tubes.* OSRAM-ROBERTSON LAMP WORKS and DURDLE, O., Brook Green, Hammersmith, London. May 29, 1917.—In a high-power tube such as is used in wireless telegraphy, a straight cathode filament is stretched between alined conductors, and elastic grid wires grouped around and parallel to the filament are held in tension between a fixed support on one cathode conductor and a sliding spring-urged support on the other cathode conductor. In

FIG.I.



the arrangement shown, each support consists of a metal disc 19 secured on a neck on a glass bead 18 and perforated near its edge for the reception of the grid wires 21. Each bead 18 may fit the cathode conductor 11 loosely and have a flared end receiving the coned end of a metal sleeve 29 accurately fitting the wire. A coil spring 24 is compressed between one sleeve 29 and a washer and collar 26 on the cathode conductor; the other sleeve 29 rests against a hook 27 holding the spring 17 which stretches the filament. The grid wires 21 are crimped at one or both ends or throughout, or are attached to one of the discs by individual tension springs. Electrostatic attraction may be counteracted by binding the grid wires together by a coil of thin wire. Each cathode conductor is sealed through the outer end of a glass tube 31 fused at its inner end to a co-axial longer and wider re-entrant tube 34. A perforated thimble 15 in the inner end of the inner tube 31 also supports the conductor.

117,284. *Röntgen-ray Tubes.* BRITISH THOMSON-HOUSTON CO., 83, Cannon Street, London. (*General Electric Co., Schenectady, New York, U.S.A.*) June 6, 1917.—In a highly-exhausted tube of the kind described in Specification 14892/13, the incandescent cathode 2^a, Fig. 2, is surrounded by a focussing device consisting of a cylinder 2^c and a hemispherical cup 2^b located so as to intercept any back discharge from the hot area of the anode 3, Fig. 1, the axis of which is at right-angles to the axis of the cathode. The design of the parts is such that the

FIG.I.

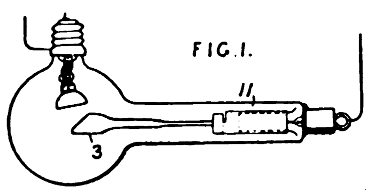
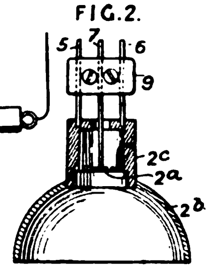


FIG.2.



main current depends on the electric pressure rather than the cathode temperature. The spiral cathode filament 2^a of tungsten, etc., may be attached to the tungsten, molybdenum, or like focussing device and to a central conductor 7. This and two wires 5, 6 carrying the focussing device are spaced by a clamp 9 and may be bent for adjustment of the position of the cathode, etc. The tungsten or other anode is supported by an iron cylinder 11 mounted on a re-entrant tube. As the electrodes enter the tube at right-angles, the high-pressure anode terminal may be directed away from the patient. Specification 10454/15 also is referred to.

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1. **THE X-RAY.** By W. J. MORTON, M.D. 1896.
2. **A B C OF X-RAYS.** By W. H. MEADOWCROFT. 1896.
3. **RÖNTGEN RAYS AND THE PHENOMENA OF THE ANODE AND CATHODE.** By EDWARD P. THOMPSON, M.I.E.E. 1896.
4. **THE RÖNTGEN RAY IN MEDICAL WORK.** By DAVID WALSH, M.D. 1897.
5. **RADIATION.** By H. H. FRANCIS HYNDMAN, B.Sc.Lond. 1898.
6. **PRACTICAL RADIOGRAPHY.** By A. W. ISENTHAL, F.R.P.S., and H. SNOWDEN WARD, F.R.P.S. 1898.
7. **Do.** **Do.** Third Edition. 1901.
8. **PRACTICAL X-RAY WORK.** By FRANK T. ADDYMAN, B.Sc. 1901.
9. **LES RAYONS DE RÖNTGEN.** By A. BECLERE. 1901.
10. **DISCHARGE OF ELECTRICITY THROUGH GASES.** By J. J. THOMSON, D.Sc., F.R.S. 1902.
11. **DIE RÖNTGENSTRAHLEN IM DIENSTE DER CHIRURGIE.** By Dr. CARL BECK. 1902
12. **DIE ELEKTRIZITÄT IN GALEN.** By Dr. JOHANNES STARK. 1902.
13. **ELECTRO-DIAGNOSIS AND ELECTRO-THERAPEUTICS.** By Dr. TOBY COHN. 1904.
14. **RADIO-ACTIVITY.** By E. RUTHERFORD, D.Sc., F.R.S. 1905.
15. **"N" RAYS.** By R. BLONDOLOT. 1905.
16. **MODERN PHYSIO-THERAPY AND X-RAY DIAGNOSIS.** By OTTO JUETTNER, A.M., Sc.M., M.D., Ph.D. 1906.
17. **THE USES OF RONTGEN RAYS IN GENERAL PRACTICE.** By R. HIGHAM COOPER. 1906.
18. **THE RÖNTGEN RAYS IN MEDICAL WORK.** By Dr. WALSH. Fourth Edition.
19. **BIBLIOGRAPHY OF X-RAY LITERATURE AND RESEARCH.** By C. E. S. PHILLIPS 1897.
20. **ATLAS DE RADIOGRAPHIE.** By P. RENARD et F. LARAN. 1900.
21. **DESCRIPTIVE CATALOGUE OF THE MUSEUM OF THE BRITISH CONGRESS ON TUBERCULOSIS.** 1901.
22. **TRANSACTIONS OF THE AMERICAN X-RAY SOCIETY.** 1904.
23. **TRANSACTIONS OF THE AMERICAN RÖNTGEN RAY SOCIETY.** 1905.
24. **Do.** **Do.** **Do.** 1906.
25. **CONDUCTION OF ELECTRICITY THROUGH GASES.** By J. J. THOMSON, D.Sc., LL.D., Ph.D., F.R.S. Second Edition. 1906.
26. **ELECTRONS; OR THE NATURE AND PROPERTIES OF NEGATIVE ELECTRICITY.** By Sir OLIVER LODGE, F.R.S. 1906.

27. **THE ELECTRON THEORY.** By E. E. FOURNIER D'ALBE, B.Sc., A.R.C.Sc. 1906.

28. **HIGH FREQUENCY CURRENTS.** By H. EVELYN CROOK. 1906.

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30. **THE RÖNTGEN RAYS IN THERAPEUTICS AND DIAGNOSIS.** By PUSEY AND CALDWELL. 1904.

31. **ELEMENTS OF RADIO-THERAPY.** By FREUND.

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33. **IONS, ELECTRONS, CORPUSCLES.** Par HENRI REUNIS et PAUL LANGEVIN, Paris. 2 Vols.

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39. **HIGH POTENTIAL AND HIGH FREQUENCY CURRENTS.** By WILLIAM BENHAM SNOW, M.D. 1905.

40. **JOURNAL OF THE RÖNTGEN SOCIETY.** Vols. I. & II. 1904-1906.

41. **ARCHIVES OF THE RÖNTGEN RAY.** 1897-1903.

42. **X-RAYS IN DIAGNOSIS.** Extra number of the "Practitioner."

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50. **RÖNTGEN RAY WRINKLES.** By LESLIE MILLER, A.M.I.E.E. 1909.

51. **HIGH FREQUENCY CURRENTS.** By H. EVELYN CROOK.

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53. **REPORT OF THE NATIONAL PHYSICAL LABORATORY.** 1908.

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57. **RADIOGRAPHY.** By S. R. BOTTONE. 1898.

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63. **MANUAL OF STATIC ELECTRICITY IN X-RAY AND THERAPEUTIC USES.** By S. H. MONELL, M.D. 1897.

64. **THE RÖNTGEN RAYS IN MEDICINE AND SURGERY.** By FRANCIS H. WILLIAMS, M.D. (Harv.). 1901.

65. **RÖNTGEN RAYS IN THE DIAGNOSIS OF DISEASES OF THE CHEST.** By HUGH WALSHAM, M.A., M.D. Cantab., and G. HARRISON ORTON, M.A. Cantab. 1906.

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78. **ELECTRO-THERAPEUTICS AND RÖNTGEN RAYS.** By MIHRAN K. KASSABIAN. Second Edition. 1910.

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96. **MATHEMATICAL PHYSICS—Vol. 1, ELECTRICITY AND MAGNETISM.** By C. W. C. BARLOW, M.A., B.Sc. 1913.

97. **THE INDUCTION COIL IN PRACTICAL WORK.** By LEWIS WRIGHT. 1897.

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103. **IONIC MEDICATION.** Second Edition. By H. LEWIS JONES, M.A., M.D. 1914.

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110. **RADIOGRAPHY. X-RAY THERAPEUTICS AND RADIUM THERAPY.** By ROBERT KNOX, M.D. 1915.

111. **CONFÉRENCES DE RADIUMBIOLOGIE FAITES À L'UNIVERSITÉ DE GAND EN 1913.** Par M. M. JACQUES DANNE, PAUL GIRAUD, HENRI COUTARD, GASTON DANNE.

112. **DONNÉES NUMÉRIQUES DE L'ÉLECTRICITÉ MAGNÉTISME ET ÉLECTROCHIMIE.** 1914.

113. **DONNÉES NUMÉRIQUES DE RADIOACTIVITÉ ATOMISTIQUE, ÉLECTRONIQUE ET IONISATION.** 1914.

114. **DONNÉES NUMÉRIQUES DE SPECTROSCOPIE SPECTRES D'ÉMISSION—PHÉNOMÈNE DE ZEEMAN SPECTRES D'ABSORPTION.** 1914.

115. **THE PRIMARY LUNG FOCUS OF TUBERCULOSIS IN CHILDREN.** By Dr. ANTHON CHON. Translated by D. Barty King, M.A., M.D. 1916.

116. **RELATIVITY AND THE ELECTRON THEORY.** By E. CUNNINGHAM. 1915.

117. **LOCALIZATION BY X-RAYS AND STEREOSCOPY.** By Sir JAMES MACKENZIE DAVIDSON, M.B., C.M. 1916.

118. **A PRACTICAL GUIDE TO X-RAYS, ELECTRO-THERAPEUTICS AND RADIUM THERAPY FOR STUDENTS AND PRACTITIONERS.** By A. E. WALTER, M.R.C.S., L.R.C.P., Major, Indian Medical Service. Thacker, Spink & Co., Calcutta and Simla. 1916.

119. **JOURNAL DE RADIOLOGIE ET ÉLECTROLOGIE. REVUE MÉDICALE MENSUELLE.** (To date.)

120. **MANUAL OF PRACTICAL X-RAY WORK.** By DAVID ARTHUR, M.D., D.Ph., and JOHN MUIR, B.Sc., M.B., C.H.B. Second Edition. 1917.

121. **ENDOCRINOLOGY.** *The Bulletin of the Association for the study of the* Internal Secretions. No. 1, Vol. 1 and to date.

122. **RADIOGRAPHY AND RADIO-THERAPEUTICS.** Vols. I. and II. By ROBERT KNOX. 2nd Edition. 1917.

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